INSTRUMENTS and AUTOMATION

Including: **The Journal of the SCMA and Simulation Council Newsletter**

also in this issue:

Low-Cost Computer 1914

Ultrasonic Analyzer 1916

Dynamic Analyzer 1918

Engine Testing 1924

Maintenance Trends 1927

Heat-Rate Testing 1928

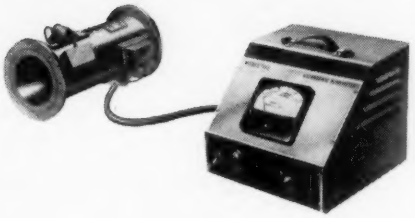
Electronic Circuitry 1937

Mill Gas Analysis 1940

Gage Protection 1946

Vol. 28, No. 11
NOVEMBER 1955

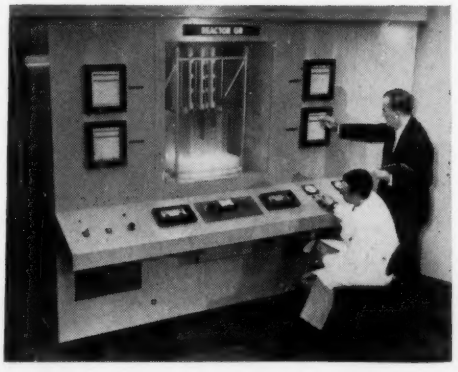
The ideal flowmeter would have no pressure drop, offer no obstruction to flow, and be unaffected by temperature, pressure, viscosity, bubbles or solids in suspension, or position of installation. The new ultrasonic flowmeter approaches the design goal . . . page 1912



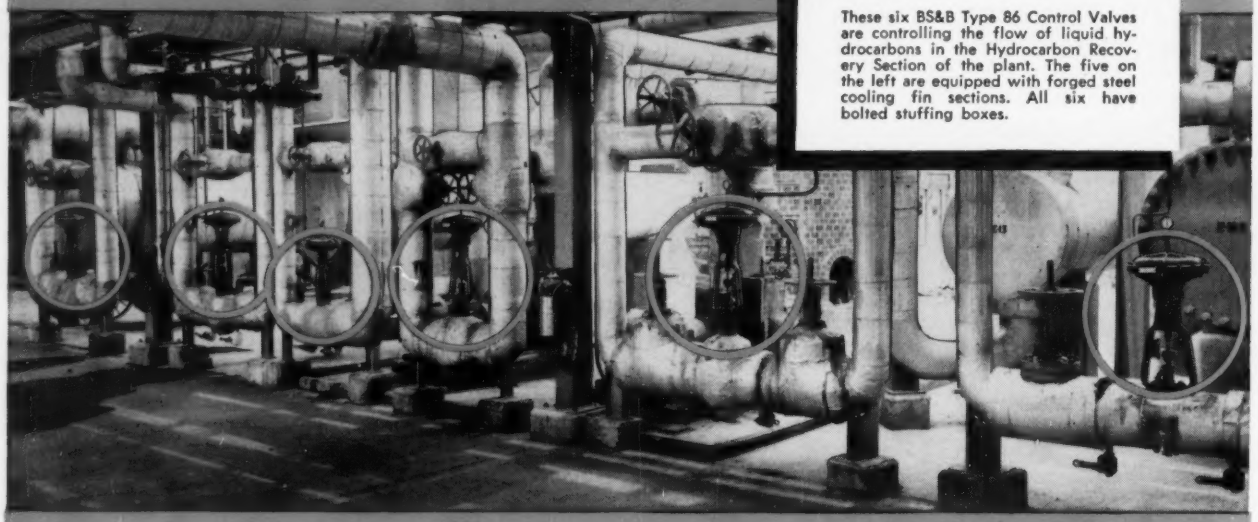
110 × 011 = 10010

New, exciting fields of logical problems open to the man who learns these simple techniques for counting and adding by 2's, who learns binary arithmetic . . . page 1930

15,000 experts in nuclear reactors will be needed by 1965; only 250 nuclear engineers will complete their training in 1955. This nuclear reactor simulator meets an urgent educational need . . . page 1923



Where *Dependability* Counts Most...



These six BS&B Type 86 Control Valves are controlling the flow of liquid hydrocarbons in the Hydrocarbon Recovery Section of the plant. The five on the left are equipped with forged steel cooling fin sections. All six have bolted stuffing boxes.

BS&B Automatic Controls Get The Job!

One of the largest petro-chemical plants in the world is that of the National Petro-Chemicals Corporation at Tuscola, Illinois. This $50,000,000 plant extracts the heavier hydrocarbons from natural gas and converts them into fuels and chemicals used in the manufacture of plastics, synthetic fibers, fertilizers, detergents and dozens of other useful products.

This plant is largely automatic, thanks in large measure to numerous BS&B Pressure Control Pilots and Liquid Level Control Pilots—and to *more than 200* BS&B Automatic Control Valves in plant service!

Valves range in size from ¾" to 8", many supplied with special body materials. Body types range from screwed globe cast iron valves to 600# ring type joint, flanged globe steel valves. Some were supplied with Haveg Bodies.

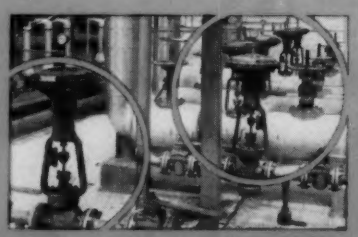
Valve trim included such materials as stainless steel and Hastelloy "B". Several valves in strategic plant locations were furnished with our Type Y Side Handwheels for emergency operation in the event of an operating medium failure. Some, destined for high temperature operation, were equipped with finned cooling sections. Many were furnished with valve positioners, either yoke mounted or mounted in the diaphragm case.

But however specialized the application, each BS&B Control was selected for the job because of its *dependability*... so vital to the successful operation of so complex a plant!

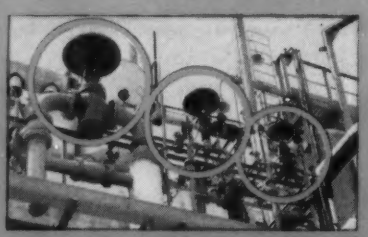
Next time you have a project in the planning stage, why not discuss the controls aspect of it in *strictest confidence* with our representative to be sure you get the *very best* controls for the job to be done?

For Better Regulation of Pressures, Temperatures, Liquid Levels or Flow, Equip Your Process With BS&B AUTOMATIC CONTROLS and SAFETY HEADS!

EFFICIENCY
OVER 60 YEARS
BS&B
RELIABILITY
ANOTHER EXAMPLE OF PRODUCT LEADERSHIP



These six Type 86's, also with bolted stuffing boxes, are controlling the flow of fuel gas to the still heater in the Hydrocarbon Recovery Section of the plant.

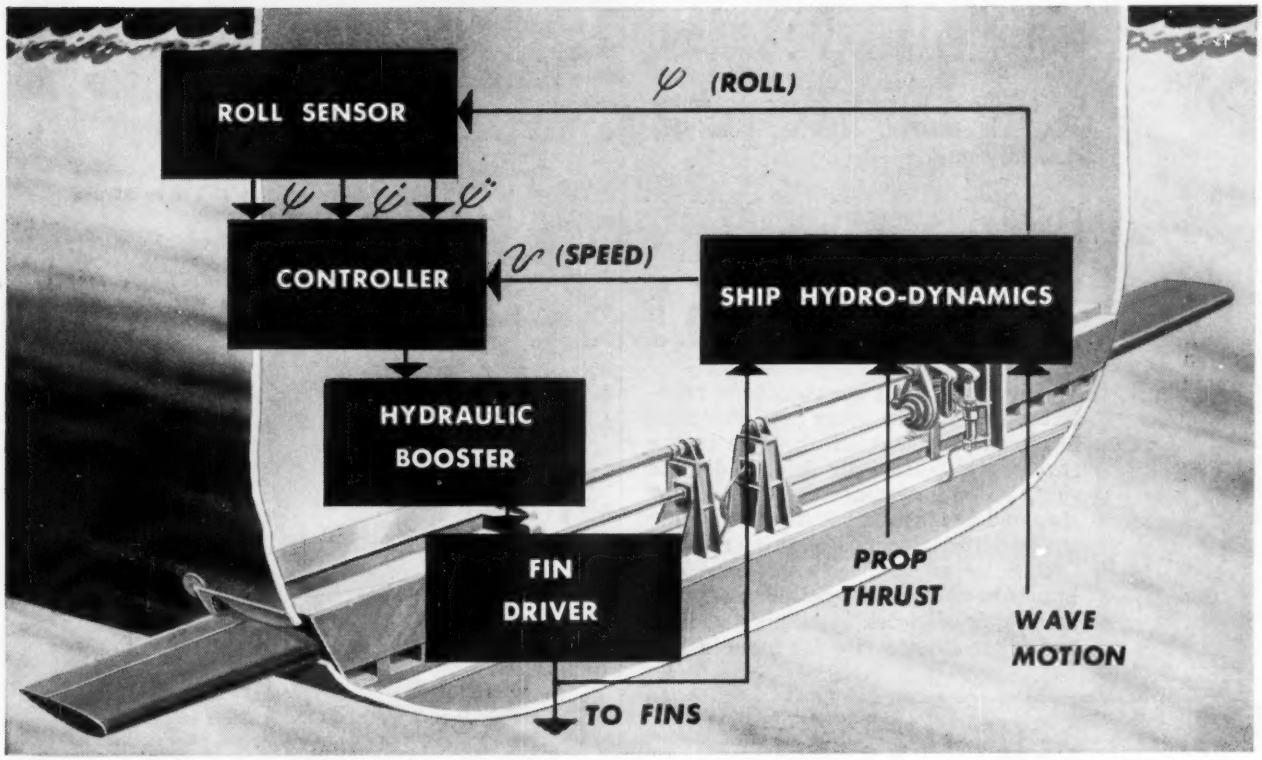


These three BS&B Control Valves are on ethylene service in the Ethylene Section of the plant. On the left is a BS&B Type 73 DC Pressure Balanced Control Valve. In the center is a Type 86 with Finned Cooling Section and Jumbo Diaphragm. On the right is a Standard Type 86 with Large Topworks.

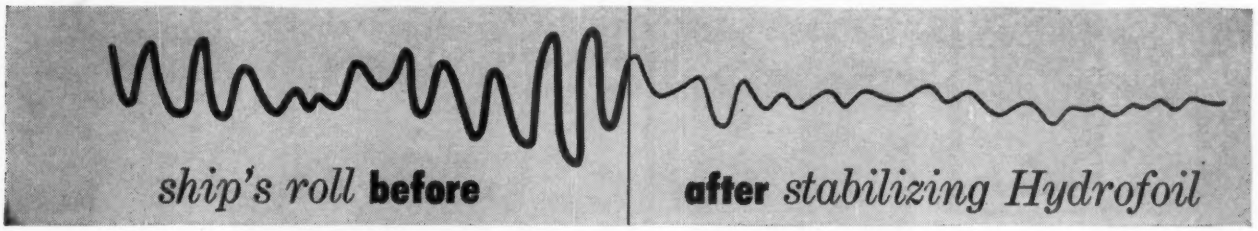
BLACK, SIVALLS & BRYSON, INC.
Controls Division, Dept. 4-V11
7500 East 12th Street
Kansas City 26, Missouri

For more information circle **1** on inquiry card.

GEDA *solves control problems*



example: How to make a ship behave



A PROVED ANTI-ROLL DEVICE for ocean-going liners means *comfort* to the passengers, *competitive advantages* to shipowners and *dynamic problems* to engineers—problems which can be handled with ease with GEDA Analog Computing Equipment built by Goodyear Aircraft.

FOR GEDA UTILIZES ordinary engineering mathematics to produce answers in the convenient variable-versus-time chart form—provides the complete transient and steady-state solution.

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see Falstrom!

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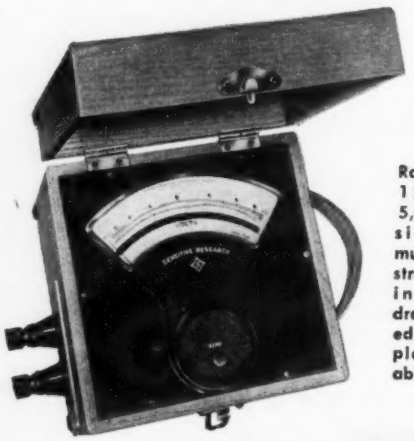
ELECTROSTATIC VOLTMETERS

True RMS reading instruments with an Input Resistance of 1 x 10^{14} ohms and an accuracy of 1% on DC and AC to R.F.

Model ESH

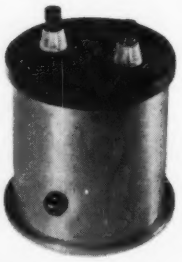
Ranges from 5 KV to 60 KV in single and multirange instruments. 6 inch hand drawn scale. Correspondence invited on ranges to 100 KV.



Model ESD

Ranges from 120 V. to 5,000 V. in single and multirange instruments. 5.2 inch hand drawn mirrored scale. Completely portable.

Model VPA



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Vol. 28, No. 11 November 1955

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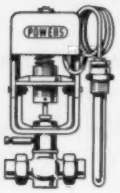

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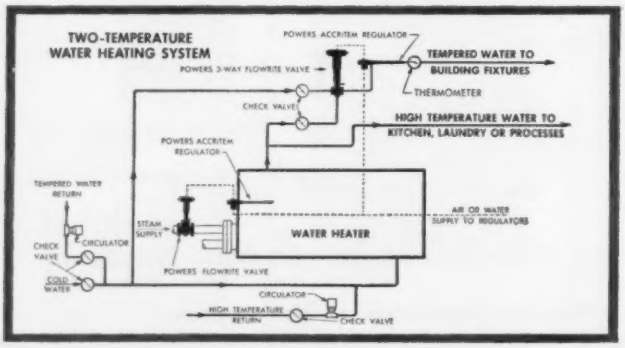

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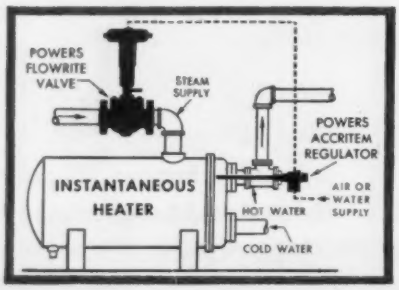

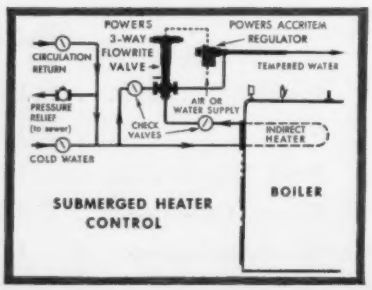

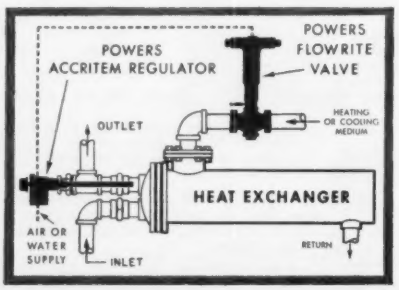

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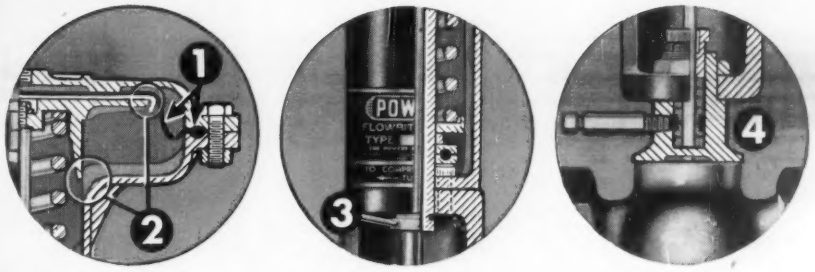

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❷ **Piston plate assembly** has a free floating thrust plate which absorbs side thrust. Closely guided piston plate maintains valve stem in accurate alignment. High tensile strength steel spring is cadmium plated and completely enclosed.

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❹ **Packing:** Deep packing space contains preformed lubricated packing readily accessible. Note lubricator.

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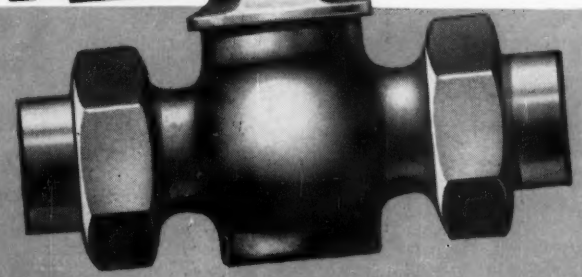

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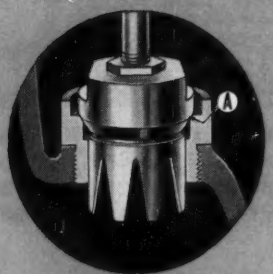

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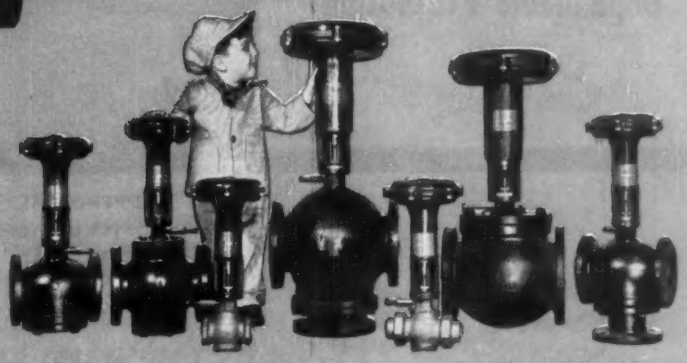

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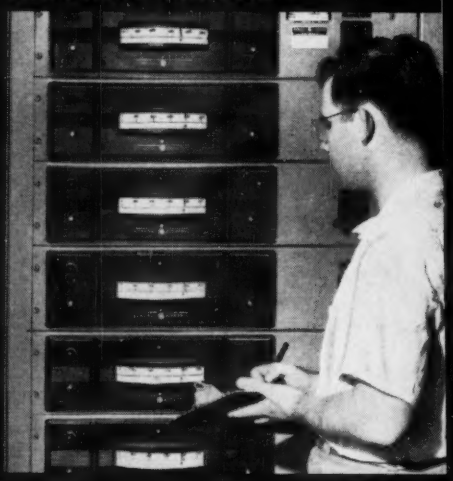
USE G-E PYROMETERS FOR ACCURATE CONTROL

General Electric Pyrometers Give Dependable Protection



TYPE HP-3 PYROMETER, a two-position controller, has positive control action, initiated by 0.1 percent in full scale movement of instrument pointer. This gives accurate readings from easy-to-read 7-inch scale. Units are available for flush or surface mounting. Indicator, controller, and protector units are plug-in type, permitting easy servicing.

For more information circle 6 on inquiry card.

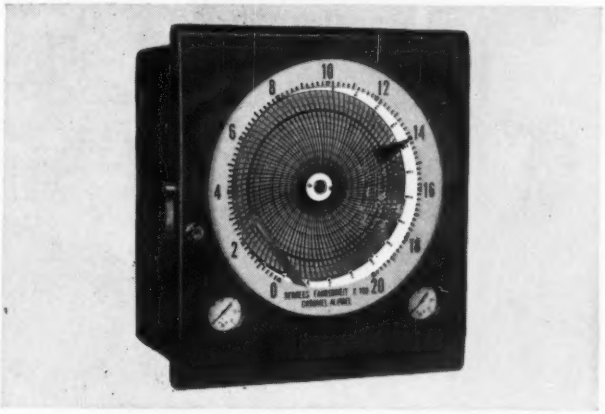
New G-E Precision Indicator Makes Temperature Checks Quick and Easy

New G-E Instrument Gives Finger-tip Scanning of up to 48 Process Temperatures in Helping You Maintain Accurate Product Control

General Electric's new precision indicator scans, by manual switching, from 1 to 48 process temperatures on multi-installations of thermocouples or resistance-bulb circuits. The new G-E potentiometer features a wide temperature range scale and is a high-accuracy, null-balancing instrument.

NEW G-E INDICATOR assures you of having less maintenance by eliminating conventionally used dry cells, slidewire and sliding contacts. This excludes such time-consuming jobs as replacing dry cells, or cleaning moving contacts.

THE MAGNETIC STANDARD provides truly continuous standardization through a revolutionary measurement-circuit design, which incorporates the high stability of a permanent magnet for a reference standard. Loss of measurement and control during standardization periods can never be experienced with constantly balancing G-E system.



G-E RECORDING CONTROLLER has same measurement-circuit design as precision indicator. Long term accuracy and precision of measurement are assured, and you get continuous dependable control with truly continuous standardization.

G-E HAND PYROMETER DESIGNED FOR WIDE USE

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- ☐ GEA-6020 Hand Pyrometer
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- ☐ GEC-1311 Type Precision Indicator
- ☐ GED-2100 New Recording Controller

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DUAL-RANGE General Electric hand pyrometer is designed for more flexible and inexpensive measurement of gas, surface and molten-metal temperatures.

EASY-TO-USE hand pyrometer accurately indicates temperature of precision castings. The instrument is light in weight with a non-slip, bayonet-grip handle.

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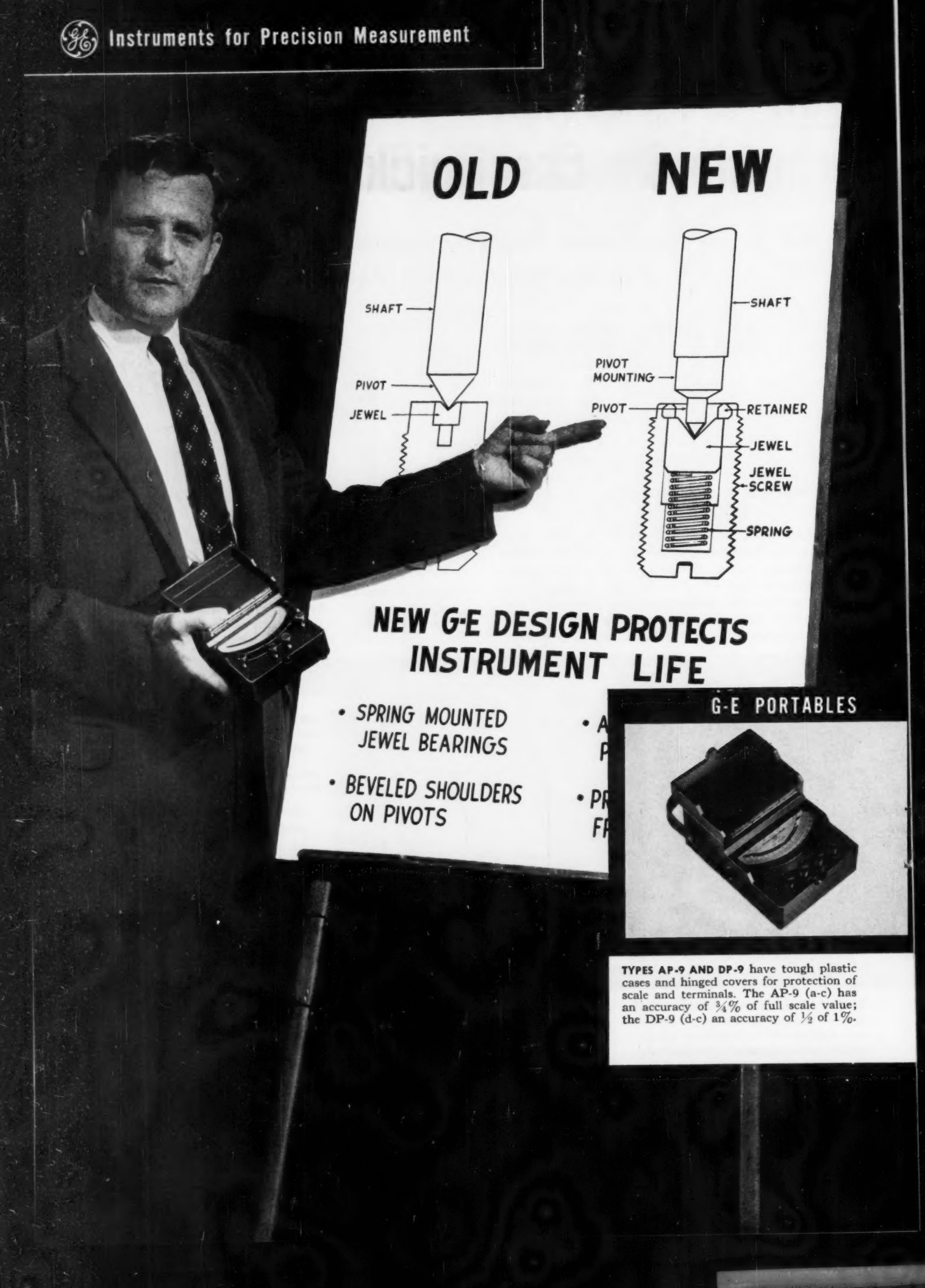

TYPES AP-9 AND DP-9 have tough plastic cases and hinged covers for protection of scale and terminals. The AP-9 (a-c) has an accuracy of ¾% of full scale value; the DP-9 (d-c) an accuracy of ½ of 1%.

New Pivot-and-bearing Design Gives Longer Life to G-E Portable Instruments

Spring-mounted jewel bearings and unique pivot mounting avoid sticky pointer action for sustained instrument accuracy

GENERAL ELECTRIC'S new pivot-and-bearing design, now in all G-E portable ammeters, voltmeters and wattmeters, assures greater dependability in portable instrument performance than ever before. Unique new construction practically eliminates pivot "mushrooming" and resultant sticky pointer action; provides maximum ruggedness for longer life.

HERE'S HOW IT WORKS—Spring-mounted jewels cushion the pressure on pivot points. Beveled shoulders on the pivots ride against retainers to protect against pivot "mushrooming."

LESS MAINTENANCE is one of the big advantages of G-E portable instruments. The new pivot-and-bearing design avoids the necessity of frequent refurbishing of damaged pivots and jewel assemblies, a major maintenance problem with most portable instruments.

IN CONVENTIONAL INSTRUMENTS, tons of pressure result between pivot points and jewel bearing surfaces every time an instrument is dropped even an inch on a table top. Such shocks cause excessive pivot wear or jewel cracking. This problem is avoided in G-E portables.

FIRST INTRODUCED in G-E switchboard instruments, this new feature achieved outstanding results. Maintenance costs were cut and instruments gained longer life with sustained accuracy. Now the same results are available in G-E portable instruments for use in laboratory and production measurements.

TYPES AP-9 AND DP-9 instruments are typical G-E testing instruments incorporating the new pivot and bearing assemblies. Type AP-9 (for a-c) and DP-9 (for d-c) are used where precise measurements are required in production, maintenance, or laboratory operations.

FOR MORE INFORMATION, contact your nearest G-E Apparatus Sales Office or mail the coupon below.

PROVIDE SUSTAINED INSTRUMENT ACCURACY WITH LESS MAINTENANCE

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- ☐ GEC-979 Portable D-C Indicating Instruments
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Street.....

City.....Zone....State.....

TYPES DP-11 AND DP-12 instruments are ideal for laboratory and production measurements. Both have break-resistant plastic cases and long 5½-inch scales for reading accuracy.

TYPE P-3 instruments provide sustained high accuracy of ⅛ of 1%. They are suitable for both a-c and d-c precision testing and perform well under adverse conditions caused by temperature, frequency, or external magnetic fields.

Progress Is Our Most Important Product

GENERAL ELECTRIC

For more information circle **7** on inquiry card.

COSTS NO MORE THAN ORDINARY OSCILLOGRAPHS

Even though the new General Electric PM-20 general-purpose oscillograph has many features not found on comparable oscillographs, it is priced at only $4,200* net.

A WIDE RANGE of frequencies—from d.c. to 6,000 cps—can be recorded at speeds from 0.8 to 100 inches/sec with the new oscillograph.

AUTOMATIC RECORD NUMBERING, timing lines, trace interruption for identification, and automatic record-length control are a few of the many additional features provided for convenient operation.

*Galvanometers and magnet assembly are not included.

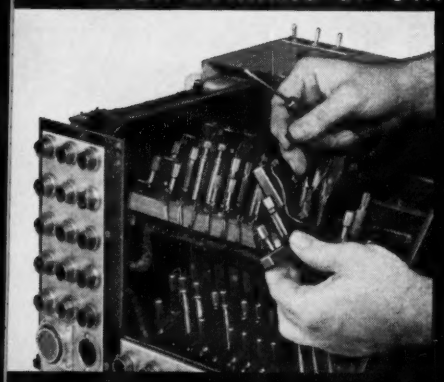
PM-20 OSCILLOGRAPH

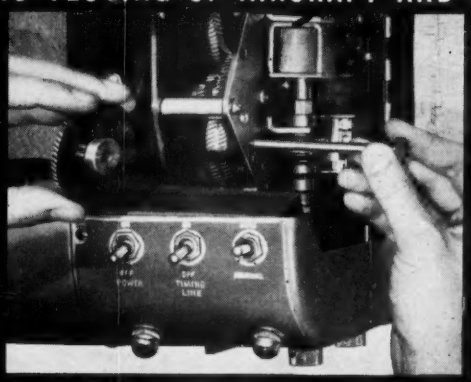
4 **EASY-ACCESS DESIGN** facilitates fast operation and maintenance. Both galvanometer banks and the gear train are

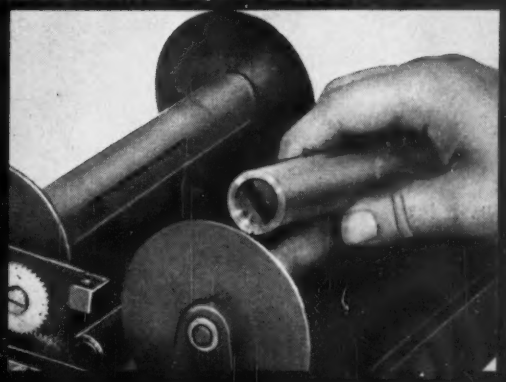
GENERAL ELECTRIC ANNOUNCES . . .

New Industrial Oscillograph with 5 Exclusive Features

FOR DYNAMIC OR STATIC TESTING OF AIRCRAFT AND INDUSTRIAL EQUIPMENT . . .





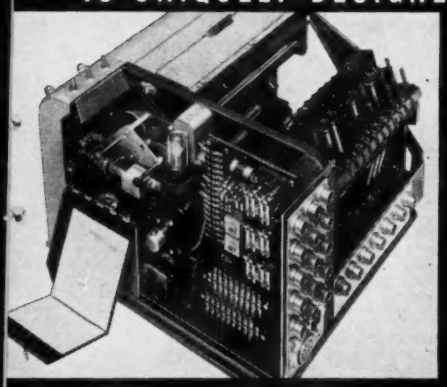


1 **71-GALVANOMETER CAPACITY** in two banks gives versatility in measuring and recording many variables simultaneously.

2 **ONLY 2 IDLER GEARS TO CHANGE** and both are always in use eliminating storage and the chance of loss. No tools are necessary to move the gears.

3 **MAGNETIC SPOOLS** in the record holder simplify loading. The spools automatically position themselves in the record holder.

IS UNIQUELY DESIGNED FOR EASY OPERATION AND MAINTENANCE



GENERAL ELECTRIC COMPANY
SECTION E585-5
SCHENECTADY, N. Y.

Please send me the following bulletin:
PM-20 General-purpose Oscillograph (GEA-6348)

Name.....

Company.....

Street.....

City.....**Zone**.....**State**.....

readily accessible through hinged doors in the lightweight aluminum case. The entire cover may be removed by loosening three fasteners.

5 **SEPARATE VIEWING LAMP** eliminates adjustments of recording lamp intensity for viewing. Lamps are easily accessible by removing the record holder.

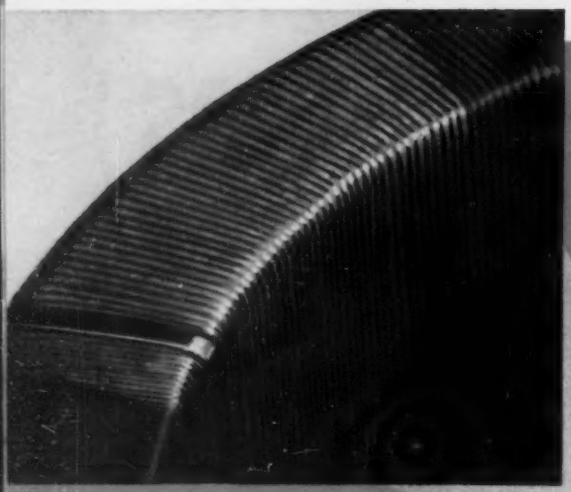
FOR MORE INFORMATION, contact your nearest G-E Apparatus Sales Office or use the coupon above to request a copy of bulletin GEA-6348.

Progress Is Our Most Important Product

GENERAL ELECTRIC

For more information circle 8 on inquiry card.

OHMITE® RHEOSTATS HAVE *Smoother Windings!*

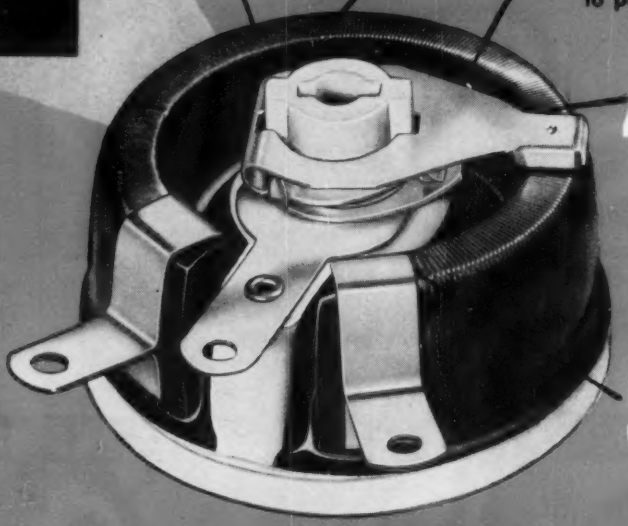


5 REASONS WHY—

1. PRECISION GROUND CORE . . . Cores for fine wire, high resistance units are ground to give a smooth, flat contour for the contact brush.

2. SMOOTH JUNCTIONS where wire sizes change between sections of tapered windings . . . less differential between wire sizes.

3. PERMANENTLY LOCKED WINDINGS . . . Core and windings are bonded together with vitreous enamel to prevent shifting of wire.



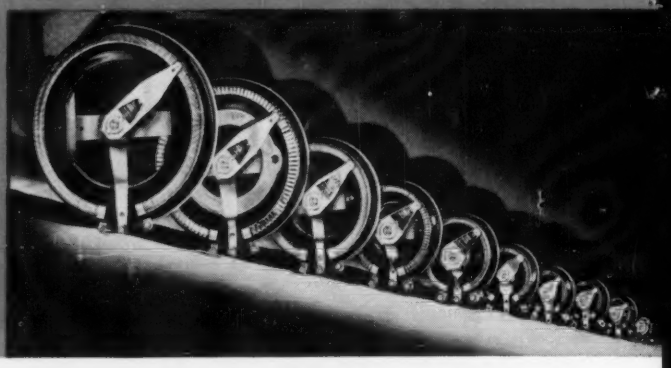
4. UNIFORM WIRE SPACING . . . Ohmite has developed special winding machines to insure uniform spacing and eliminate crossover of adjacent turns on fine wire units.

5. FLUSH TERMINALS . . . Terminals are flush with windings . . . brush glides smoothly from windings to terminal.

See for yourself! Examine an Ohmite Rheostat first hand. Compare its smoother resistance windings. Turn the knob and note how easily and smoothly the contact brush glides over the rheostat windings.

There's less wear on the resistance wire and on the contact brush. The brush makes contact with all of the turns and the resistance varies smoothly and uniformly as the shaft is turned. Every Ohmite Rheostat is *individually tested* on ultrasensitive electronic instruments to assure perfect contact between the winding and the contact brush.

Standardize on Ohmite Rheostats for unsurpassed dependability, smoothness of operation, and long life.



A COMPLETE LINE OF RHEOSTATS

from 25 to 1000 watts. Also available to meet MIL-R-22A requirements in *each* of the 26 type designations.

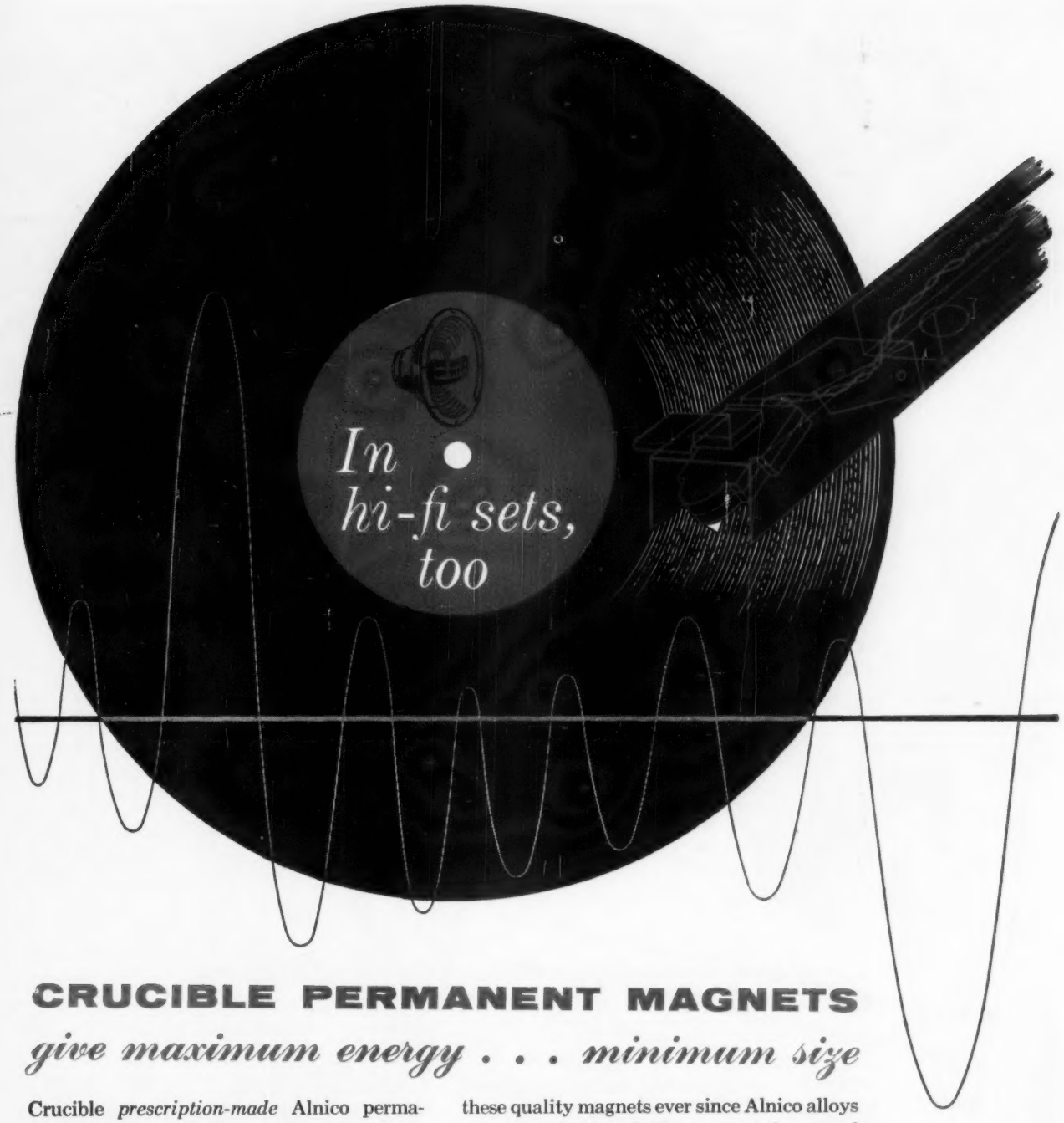
Write on company letterhead for Catalog and Engineering Manual No. 40.

Be Right with OHMITE®

OHMITE MANUFACTURING COMPANY, 3615 Howard Street, Skokie, Illinois (Suburb of Chicago)

For more information circle 7 on inquiry card.

RHEOSTATS • RESISTORS • RELAYS • TAP SWITCHES



CRUCIBLE PERMANENT MAGNETS

give maximum energy . . . minimum size

Crucible *prescription-made* Alnico permanent magnets provide *consistently higher* energy products.

This means greater design freedom . . . more compact products for manufacturers of high-fidelity sound equipment, instruments, controls, motors, and other magnet equipped devices.

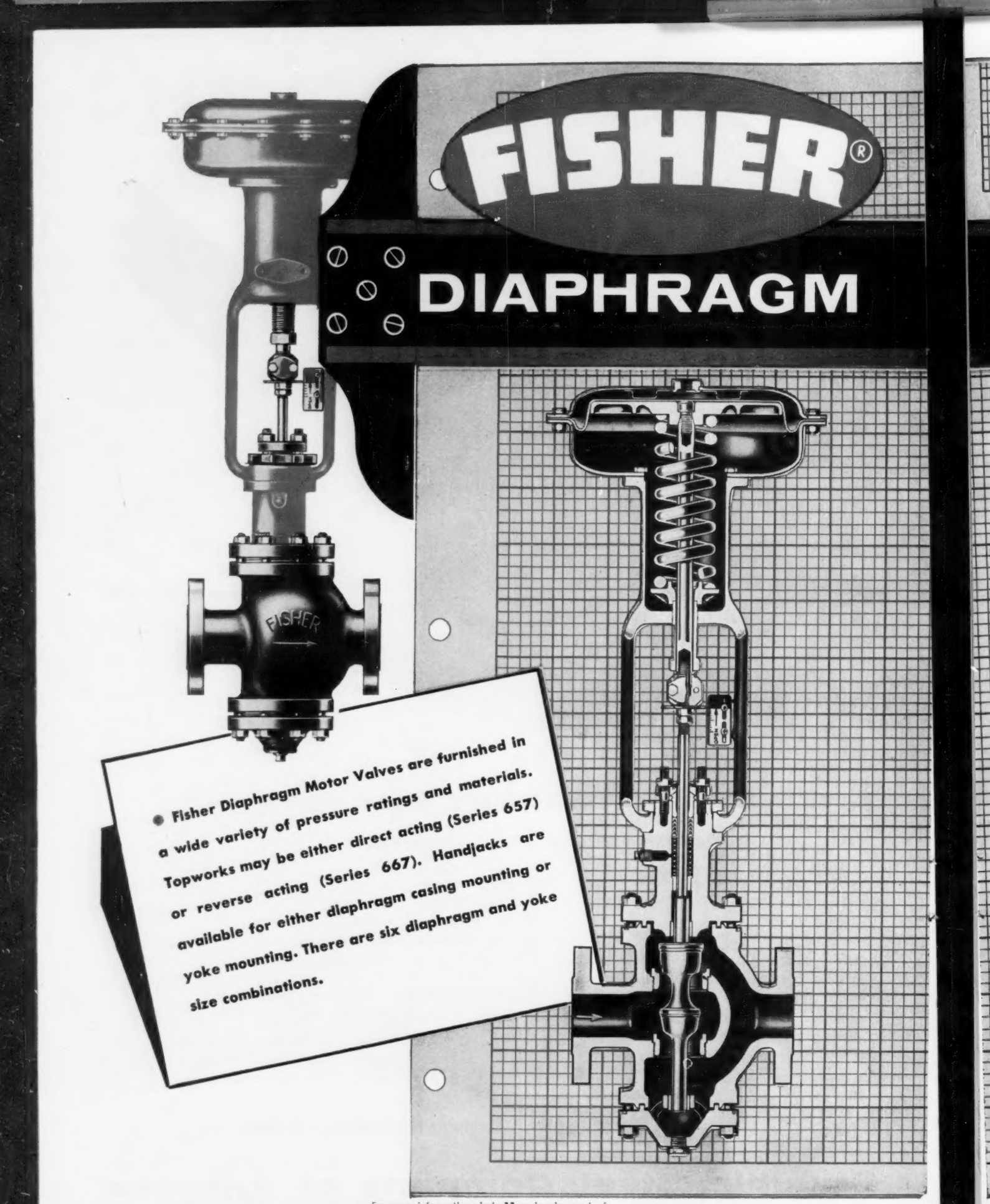
Crucible has been a leading producer of these quality magnets ever since Alnico alloys were first developed. You can get them sand cast, shell molded, or investment cast to meet every size, tolerance, shape and finish need.

Next time you need top quality magnets, or help with magnet applications, call Crucible. *Crucible Steel Company of America, Henry W. Oliver Building, Pittsburgh 30, Pa.*

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

For more information circle **10** on inquiry card.


FISHER®
DIAPHRAGM
FISHER
● Fisher Diaphragm Motor Valves are furnished in a wide variety of pressure ratings and materials. Topworks may be either direct acting (Series 657) or reverse acting (Series 667). Handjacks are available for either diaphragm casing mounting or yoke mounting. There are six diaphragm and yoke size combinations.

For more information circle **11** on inquiry card.

Improved

MOTOR VALVES

Improved PERFORMANCE FEATURES

- Bolted-clamp type stem connection allows stem adjustment of 50% of total travel. Can be disconnected in the field without stem damage. Will not shake loose from vibration or rotational inner valve forces.

- Rugged body to yoke connection with hammer lug nut. Topwork can be removed without disturbing stuffing box.

- Specially designed Buna N molded diaphragms with Nylon insert retain superior flexibility at low ambient operating temperatures. Provides linearity between operating pressure signal and travel, and gives maximum effective area.

- Bolted gland stuffing box with Teflon packing.

- Stainless steel clear view travel indicator.

- Spring ranges: 3 to 15 psi; 6 to 30 psi.

FISHER GOVERNOR COMPANY • Marshalltown, Iowa

WORLD LEADER IN RESEARCH FOR BETTER PRESSURE AND LIQUID LEVEL CONTROL

FISHER

Our 75th ANNIVERSARY

For more information circle 11 on inquiry card.

for improved readability, specify
the new **LEWIS**

LONG SCALE

aircraft temperature indicators

- Standard AND10412 cases
- Scale arc approximately 250°
- No auxiliary components
- No vacuum tubes
- Operate the same as conventional thermocouple type or resistance type temperature indicators
- Interchangeable with conventional temperature indicators, use standard resistance bulbs or thermocouples and leads
- Made to Military Standard Specifications
- Tested and Approved

COMPARE the improved readability of these long scale indicators with these . . .

Conventional indicators

Recognizing the need for improved readability without increasing panel space requirements, The Lewis Engineering Company has developed these completely new Aircraft Temperature Indicators both in the Thermocouple Thermometer type and in the Resistance Thermometer type.

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naugatuck, connecticut

For more information circle 12 on inquiry card.

Trends...

INSTRUMENTS and AUTOMATION

Trends in research: in 1920 about 10,000 persons were engaged in research costing $29 million; by 1940 there were 70,000 persons in research worth $234 million; in 1955 about 375,000 persons are working on projects totaling $4 billion. Great need in field of research is for able technicians to assist scientists and engineers; State of Pennsylvania has authorized area technical schools to help meet this need. Such schools can become of critical importance; watch them closely.

FTC report states that merger rate in 1955 in the instrument and electronics fields is more than twice that for 1954, and increasing.

Electrically operated equipment (machinery, appliances, etc.) has increased annual production from $5.7 billion in 1939 to $39.8 billion in 1955; is expected to reach $70 billion by 1970. Of 2000 basic types of products listed in U. S. Standard Industrial Classifications, 74% are motor operated.

Gross national product is at present level of $370 billion for 1955; is expected to reach $562 billion by 1970.

Small and medium digital computers are finding applications at expanding rate. Watch for exciting developments from Underwood Corp. in field of medium-sized digital computer, file computer, solenoid-operated automatic typewriters, and high-speed data recording.

Graphic circuitry and printed wiring is expanding rapidly. GE Electronic Components Dept. plans production of 1 million square feet of printed wiring boards for 1956.

Cost of instrumentation in chemical plants has risen from 2% of total plant costs to 7 to 10% of total plant costs within ten years, says V. Hanson of duPont.

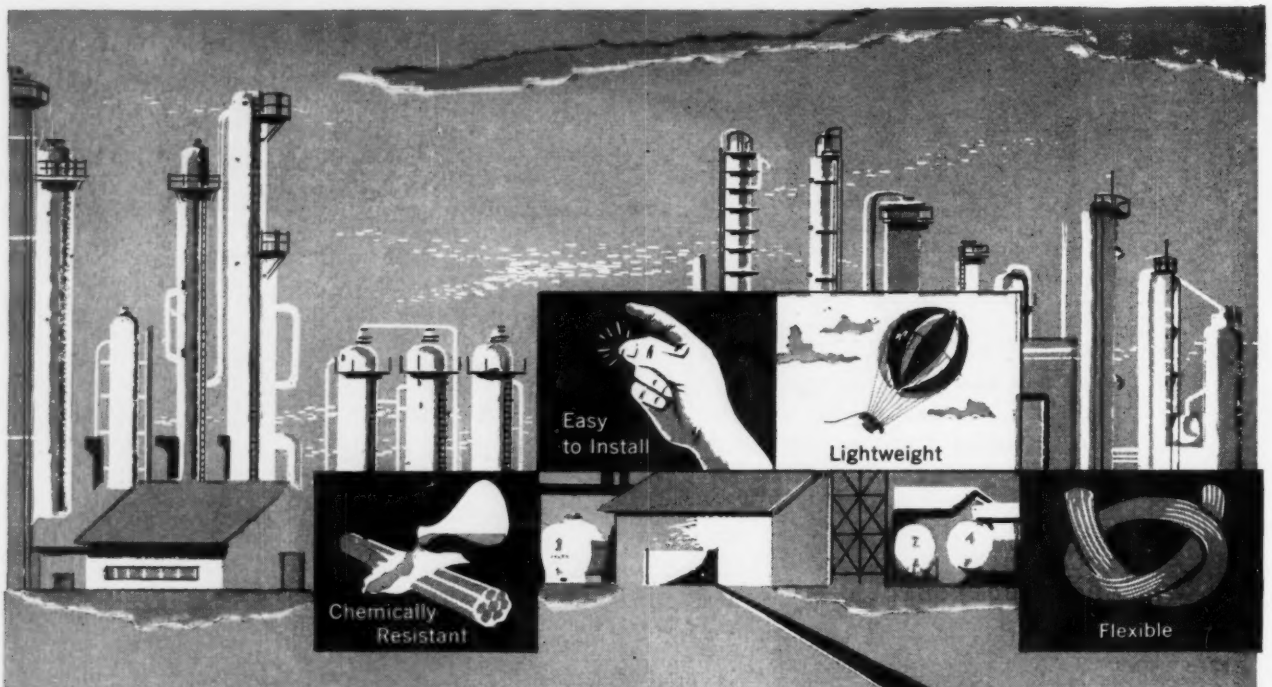
Gas-filled tube sales have increased from $10.5 million in 1951 to $15.5 million in 1954, with hydrogen thyratrons responsible for most of increase.

USA has more than 50 million telephones; more than rest of the world; adds more than 2 million every year.

Six to ten satellites will be launched by 1958 says Professor H. E. Newell, Jr., U. S. Naval Research Lab. Basketball-sized globe will be packed with instruments.

Steel ingot output in 1954 was 88.3 million tons, an increase of 3.4 million tons over 1947 output—yet 13% less coal, 9% less scrap, 6% less limestone, and 4% less ore was used in 1954 than in 1947, despite 4% increase in steel output. Reason: better ores, better techniques, and better instrumentation.

The worker of today is the technician of tomorrow--R. Rimbach



DEKORON

Poly-Cor

harness

Now you can whip high instrument tubing installation and replacement costs in your plant—with Dekoron Poly-Cor®. That's because the chemical resistance of plastic even outlasts expensive alloy tubing . . . because its lighter weight and flexibility make it a snap to install without special tools . . . because you can install practically any number of tubes at one handling, just like electric wiring. You can't lose with Dekoron Poly-Cor — it cuts your investment because of its lower installed cost, cuts your maintenance because it lasts years longer.

Tube up with DEKORON completely

Dekoron products now include single and multiple line metal tubing with plastic coating, multiple tube all-plastic instrument line harness (above), flat 10-tube "ribbon," fittings and junction boxes.

Dekoron® products

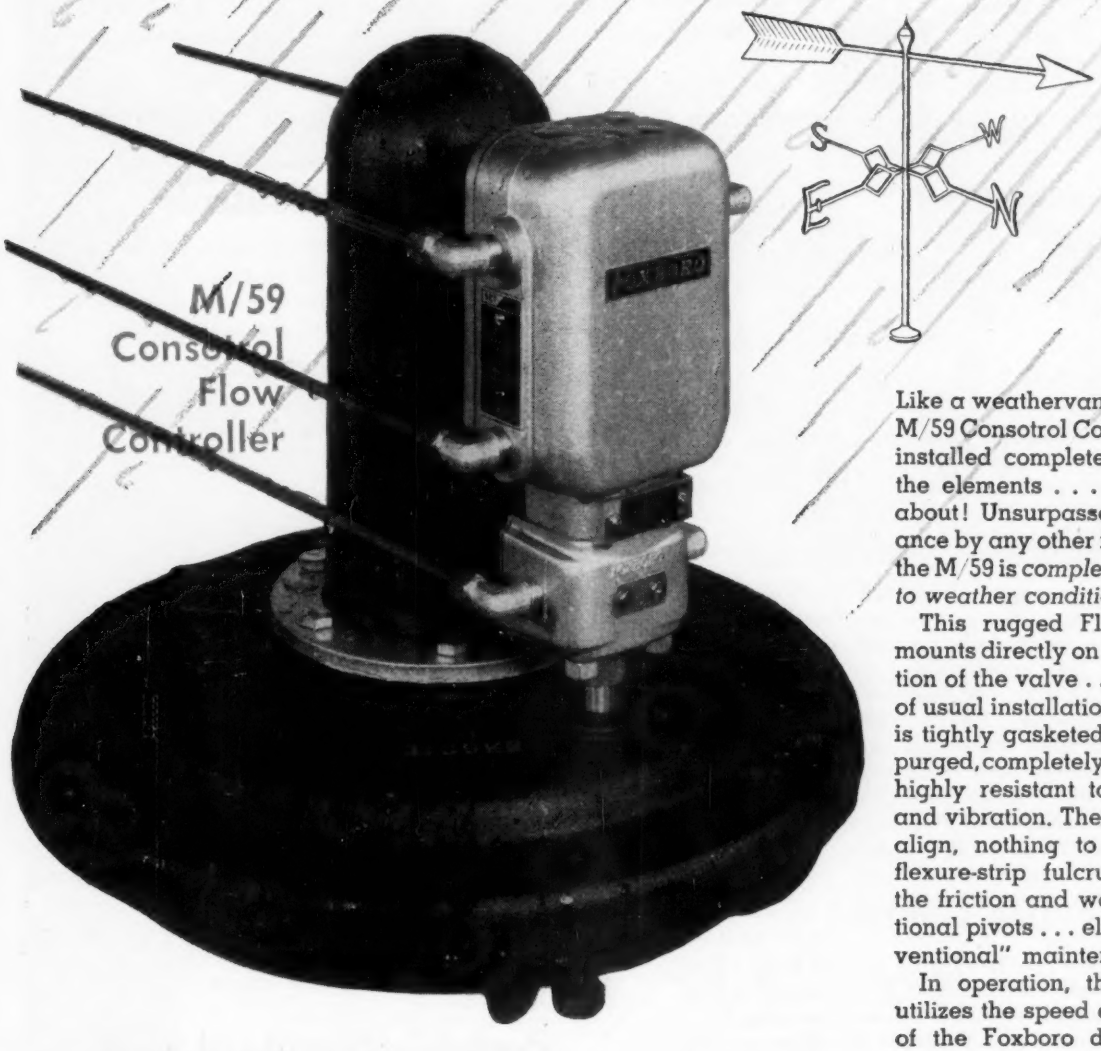
QUALITY • RESEARCH • SERVICE

SAMUEL MOORE & COMPANY

DEKORON PRODUCTS DIVISION • MANTUA, OHIO

For more information circle 13 on inquiry card.

This Controller requires no more attention than a weathervane!



Like a weathervane, the Foxboro M/59 Consotrol Controller can be installed completely exposed to the elements . . . and forgotten about! Unsurpassed in performance by any other flow controller, the M/59 is *completely indifferent to weather conditions.*

This rugged Flow Controller mounts directly on the air connection of the valve . . . at a fraction of usual installation cost. Its case is tightly gasketed, continuously purged, completely weatherproof, highly resistant to dust, fumes, and vibration. There's nothing to align, nothing to wear out. A flexure-strip fulcrum eliminates the friction and wear of conventional pivots . . . eliminates "conventional" maintenance.

In operation, the M/59 fully utilizes the speed and sensitivity of the Foxboro d/p Cell Flow Transmitter . . . does away with transmission lag . . . gives fastest recovery from process upsets. For the *complete* story, write today for Bulletin 470.

"Live-Balance" Control on any fluid with any size valve motor.

Lowest first cost. Lowest installed cost.

Lowest maintenance cost.

Unique Simplicity — exclusive design permits fixed, optimum proportioning and reset values for liquid flows. Adjustable reset optional for gas or steam flow.

THE FOXBORO COMPANY, 4611 NEPONSET AVENUE, FOXBORO, MASS., U.S.A.

FOXBORO
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FLUID FLOW CONTROLLERS

FACTORIES IN THE UNITED STATES, CANADA AND ENGLAND

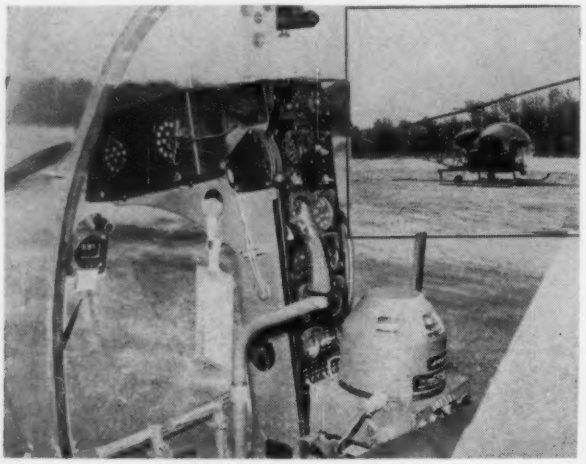
For more infromation circle 14 on inquiry card.

News...

INSTRUMENTS and AUTOMATION

Historic Event—An Airborne Gyrocompass

FORT BELVOIR, VA.—The north-seeking gyrocompass has been a basic shipborne navigational aid—but has not previously been used in aircraft because the



rapid acceleration changes of aircraft have precluded such use. Thus, news that a true north-seeking gyrocompass has been successfully operated in flight is an historic event of first importance.

The news comes from the Engineer Research & Development Laboratories (ERDL), Fort Belvoir, Va., where the gyrocompass was tested in helicopter flight. The first trial is shown here. A closeup of the gyrocompass is shown mounted on the cabin floor. The apparatus is the new Arma Subminiature Gyro-Compass, furnished by Arma, Div. of American Bosch Arma Corp.

Traffic Control

ATLANTIC CITY, N. J.—Traffic control from a central headquarters was demonstrated at recent annual convention of American Bridge, Tunnel and Turnpike Association, Atlantic City. Taller & Cooper, Brooklyn, specialists in traffic control, displayed an integrated traffic control system based on ITV. Also revealed by Taller & Cooper was an automatic toll-collection and accounting system for toll roads, tunnels, and bridges, called "Tollamation."

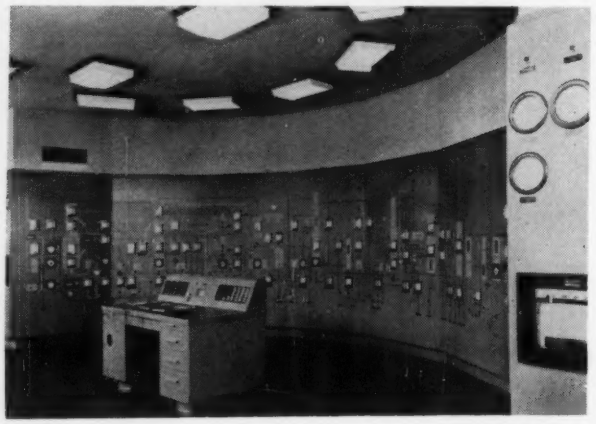
Revised Stainless-steel Designations

NEW YORK, N. Y.—The first major changes since 1952 in the published designations for stainless steel types have been announced by the American Iron and Steel Institute. Standard types of stainless steels are numbered in the 300 and 400 series for the convenience of steel makers and users. Six types have undergone changes in the maximum allowable carbon content provided for by the standard compositions. These are 301, 302, 302B, 316, 317 and 446.

Machinability received close attention, with the establishment of three new type numbers for selenium-bearing stainless steels—303Se, 416Se, and 430F Se. Designers and fabricators now can specify by type number their free-machining stainless steel types with additions of sulphur or selenium.

Salle de Controle

BRUSSELS, BELGIUM.—European refineries are fast adopting the latest American technological advances. The photo below, which might have been taken in any U. S. refinery, is actually a view of the control room at the



Societe Industrielle Belge des Petroles of Brussels. The colorgraphic control panel is believed to be the first of its kind to be used in a European refinery. Designed by Minneapolis-Honeywell engineers, the panel and control system for the Belgium refinery covers a catalytic cracking and polymerization unit. It was constructed by the French subsidiary of Lummus. The S.I.B.P. refinery is reputed to be one of Belgium's largest.

Portable Standard Cell Comparator

WASHINGTON, D. C.—The National Bureau of Standards has devised a convenient, inexpensive method for maintaining the standard volt in a laboratory to 0.002 percent. Developed by A. W. Spinks and F. L. Hermach of the NBS electrical instruments laboratory, the equipment consists essentially of four saturated standard cells, a temperature-controlled airbath, and a thermofree potentiometer for intercomparing them.

Saturated standard cells (containing an excess of cadmium sulphate) usually employed for this purpose are much more stable than the common unsaturated cells. However, due to their negative temperature coefficient

Continued on page 1808

MODEL MA640

MODEL MA2850

MODEL MA65

RUGGED • ACCURATE • TUBELESS

MAGNETIC AMPLIFIER DC SOURCES

(MA-NOBATRONS*)

Sorensen MA-NOBATRONS* have been designed for industrial applications and unattended installations where the utmost in maintenance-free service is required.

S P E C I F I C A T I O N S

	MODEL MA65	MODEL MA640	MODEL MA2850
INPUT	105-125VAC, 1Ø, 60 cycles		190-230VAC, 3Ø, 60 cycles 4-wire wye.
OUTPUT	6VDC, adj. ±10%	4.5-7.7VDC, adj.	23-32VDC, adj.
LOAD RANGE	0-5 amperes	0-40 amperes	0-50 amperes
REGULATION	±1.0% for any combination of line and load conditions		
RECOVERY TIME	0.15 seconds under worst conditions	0.2 seconds under worst conditions	0.5 seconds under worst conditions

Contact your local Sorensen representative, or write for further information. If you have special requirements in magnetic amplifier DC sources, write or call the Applications Engineering Department, and your problem will receive prompt attention.

SORENSEN & COMPANY, INC. • 375 FAIRFIELD AVE., STAMFORD, CONN.

*Reg. U.S. Pat. Off.

CONTROLLED POWER FOR RESEARCH AND INDUSTRY

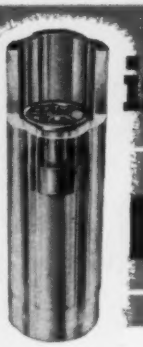
SORENSEN

For more information circle **15** on inquiry card.

What Type Flowmeter is Right for You?

COX

TYPE 8
TYPE 10
TYPE 12
TYPE 14



FLOWMETERS

Single Stage TYPE 8

Ideal for measuring rate of flow in production line processes where accuracy and performance must be matched by low cost operation.

All have *"Inner Wall Guide"* Design for Perfect Match of Tube and Float

If, like many of our customers, you depend upon flowmeters primarily for production, the Single Stage **Cox Type 8** provides the right combination of accuracy, readability, and quick response so essential for low cost performance of this type. Lightweight, dependable, and easily operated, the variable area Type 8 is ideal for a wide range of production processes.

Should you require a research-type flowmeter capable of indicating very low flows in engines, pumps, carburetors, etc., the Multiple Stage **Type 10** is the answer. Used extensively in automotive engine laboratories, it is accurate within ± 1% of the reading at any point on the scale.

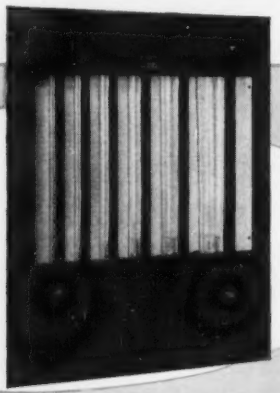
Where high capacity, high accuracy is essential, Cox Multiple Stage **Type 12 Flowmeters** — 40, 90, and 100 Series — and the high pressure **Type 14** are unsurpassed. Logarithmic scales provide the same degree of readability (from ¼% to 1% depending upon the Series) at *all* points throughout the flow range. Capacities up to 130000 PPH are available, where needed. And like all Cox Flowmeters, the Type 12 and Type 14 feature "Inner Wall" guides, integral with the tapered tube, which accurately match contours of the float, and assure stability and repeatability of float position. Explosion-Proof backlighting with translucent scales for maximum visibility available on the Type 12 and Type 14.

Multiple Stage TYPE 14

A high pressure Multiple Stage flowmeter for pressures up to 1000 p.s.i. Uses the same logarithmic scales as the Type 12 and provides unsurpassed readability. Capacities to 36000 PPH.

Multiple Stage TYPE 10

Combination laboratory-industrial flowmeter. Developed to handle low flow rates and varying temperatures and viscosity encountered in engine, carburetor and pump testing.



40 Series

Multiple Stage—TYPE 12

Available with bypass orifice which greatly raises maximum range (up to 90000 PPH) without increasing number of tubes. Like all Cox Flowmeters, the Type 12 is calibrated on Cox Calibrating Stands—accepted primary standard of calibration throughout the automotive and aircraft industries.

Write for FREE LITERATURE

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MAKERS OF COX INSTRUMENTS SINCE 1912: CARBURETOR FLOW STANDS · ENGINE INDICATORS · FLOWMETER CALIBRATING STANDS · FUEL NOZZLE TEST STANDS · MAGNETIC THICKNESS GAGES · VIBRATION RECORDING EQUIPMENT · BALANCED ELECTRONIC EQUIPMENT FOR PRESSURE AND VIBRATIONS

For more information circle **16** on inquiry card.

now FOR DC OR RESISTANCE INPUT

MODEL 200-A uses an input of 10,000 ohm resistance potentiometers as an input transducer providing 10 to 1 scale expansion and origin positioning. Available standard digital input accessories are essentially inputs of this type. Any resistance potentiometer will provide an analog input for this configuration.

MODEL 200-B, used for D.C. signal input, has full scale sensitivities of 5 millivolts and an input impedance of 1,000 megohms. Utilizing standard reference cells, this model provides drift-free operation. Available external reference voltages may be substituted. A plug connection is provided to facilitate the quick interchangeability of input sections.

now FOR SIMPLIFIED OPERATION

Precision Vernier Dials provide an accurate method for obtaining fine adjustment during operation. Optional point plot or continuous line plotting is a feature of both models. Selection is by front panel manual control. A new, simplified pen of one-piece design-used for point or continuous plotting—eliminates bottles and tubes, permits rapid changing of ink colors. Independent action of the X and Y axis is achieved with Librascope's unique "Floating Gear Train." No cables, tapes or lead screws to cause lost motion, cable stretching or drifting out of alignment. The 120° concave cylindrical plotting surface provides full visibility . . . is completely illuminated.

now FOR WIDER APPLICATION

These fast, dependable general purpose plotters feature 0.1% accuracy, are suited for wide applications where rapid graphic presentation of data is required, such as: laboratory testing, computers, data handling systems, wind tunnel, missile tracking and quality control testing of transistors and other electronic components. Input selection includes Punched Card and Tape Converters, Decimal Keyboards and Binary Converters. Model 200-A can plot from Flexowriter tape in any code or directly from the Tape Punch cables of many digital computers. Subchassis can be supplied to handle time-shared X versus Y plots, or other special circuitry. Write today for details.

LIBRASCOPE X-Y PLOTTER

HIGHEST ACCURACY FOR GRAPHIC DATA HANDLING

Greater input flexibility | For desk or rack mounting

NEW LIBRASCOPE PUNCHED TAPE CONVERTER
Operates from a punched tape reader—Specially designed for Librascope X-Y Plotters—This unit is adaptable to other plotters.

LIBRASCOPE X-Y DECIMAL KEYBOARD
Presents all three-decimal pairs for each axis with associated plus minus keys. Features Librascope designed positive-action self-aligning contacts.

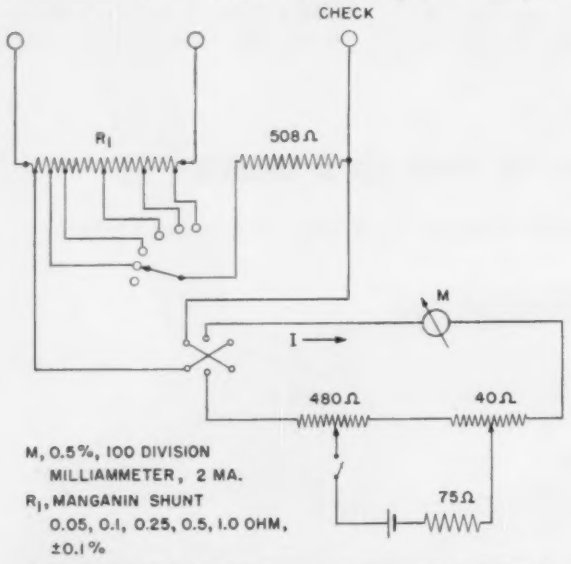
LIBRASCOPE PUNCHED CARD CONVERTER
Converts punched card data to analog form for input to X-Y Plotters. Automatic Position for feeding 50 punched cards per minute.

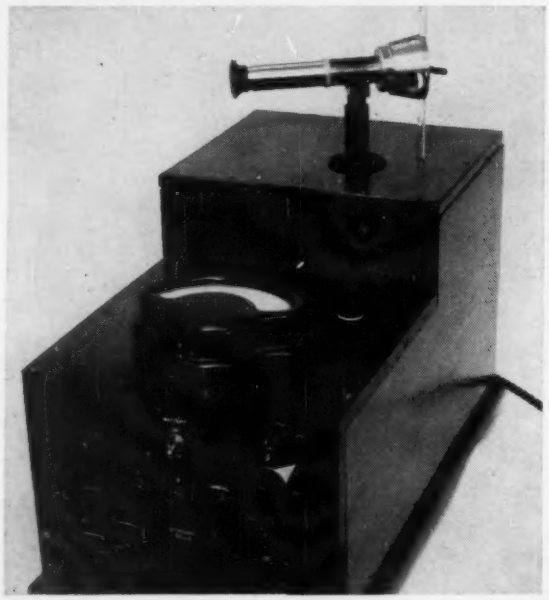
LIBRASCOPE INCORPORATED • 808 WESTERN AVENUE • GLENDALE, CALIFORNIA

For more information circle **17** on inquiry card.

some form of constant temperature enclosure is necessary. NBS has designed an air bath device, which is relatively lightweight and inexpensive, to take the place of the conventional oil bath. The low-power telescope shown reads the thermometer extending into the controlled enclosure.

A built-in Lindeck potentiometer is used to compare the emf's of the cells. To perform an intercomparison, the standard cell of known voltage and the cell of unknown voltage are connected in series, emf's opposing, and the small difference in their potentials is measured with the potentiometer. The negative terminals of the two cells are connected to each other, and the positive terminal of the unknown cell is connected to one post of the potentiometer. The positive terminal of the known cell is connected through a galvanometer and a switch to a second post of the potentiometer. When the voltages are balanced, the difference in the emf's of the two cells is equal to the product of the milliammeter reading and the resistance value of the shunt for the taps used. A reversing switch indicates by its position which cell has the higher emf. By applying this difference to the value for the known cell, the emf of the unknown cell is determined.





Bailey Acquires "Heat Prover"

CLEVELAND, OHIO.—Bailey Meter Company, Cleveland, has purchased the Cities Service "Heat Prover"

combustion analyzer, a portable 25-lb instrument designed for analyses of a gas sample for oxygen and combustibles content. The instrument uses the catalytic combustion principle; the oxygen and combustibles-content indicators have range spans of 4% and 20%.

Protection Against Impact

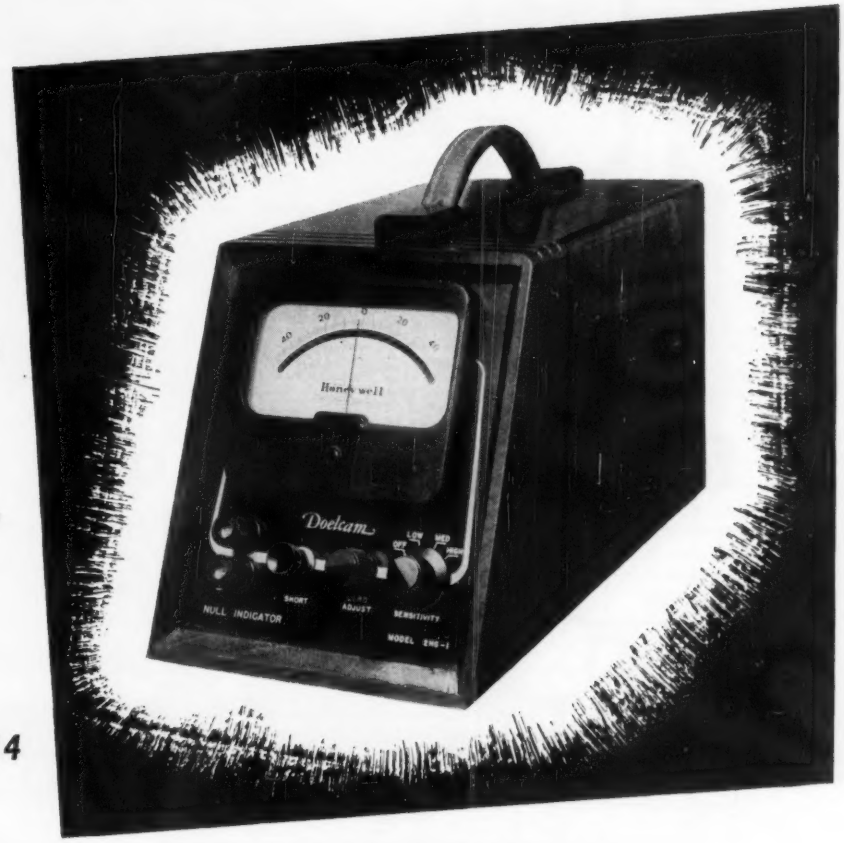
HILLSIDE, N. J.—Western Electric Company, Hillside, ships these $40,000 repeater stations (for use on trans-Atlantic cable) by airplane, rail, and ship. Possible

damage could interrupt trans-Atlantic communication and necessitate fabulously expensive repairs. Damage in transit must be guarded against. Hence Western Electric attaches this small "Impact-O-Graph" recorder to each repeater; the three masses on the instrument record maximum accelerations suffered by the unit in the three basic degrees of freedom. A comparison of the record before and after shipment (as done by inspectors) tells if shipment was made without excessive impact to the precision equipment. The Impact-O-Graph is made by Impact-O-Graph Corp., 1900 Euclid Ave., Cleveland, Ohio.

Continued on page 1812

CAN YOU MEASURE NOTHING ACCURATELY?

Now *Doelcam* Magnetik Null Indicator



EXCLUSIVE FEATURES

- **High Sensitivity**
- **Linear Deflection**
- **Magnetic Converter**
- **Isolated Input**
- **Low Noise Level**

Write for Bulletin N14

THE DOELCAM Magnetik Null Indicator, Model 2HG-1, is *both* a null balance detector and a linear deflection indicator. It may be used as either a low level laboratory instrument where *accurate null* measurement is important, or as a fast measuring production test instrument where *linear* off-balance readings and ability to withstand rough usage are essential. All around improved performance is achieved by use of the unique DOELCAM Second-Harmonic Magnetic Converter as the input modulator.

CHARACTERISTICS

HIGH SENSITIVITY: 2 Microvolts per division. 0.003 Microamperes per division.

PROPORTIONAL DEFLECTION: Linearity over full scale range is within 5% accuracy.

ISOLATED INPUT: Input terminals are isolated from chassis and circuit ground.

LOW NOISE LEVEL: Less than 2 microvolts equivalent input. Insensitive to 60 or 120 cycle pickup.

EXCELLENT STABILITY: Zero drift less than 1 division per hour.

INDEPENDENT OF LINE VOLTAGE: No observable drift or change in sensitivity for line variations from 105 to 125 volts.

QUICK READING: Time constant of less than 1 second.

RUGGED: Not damaged by overrange of 1.5 volts d-c.

POLARITY SENSITIVE: Zero-center mirror-scale meter for polarity sensing measurements.

LOW MAINTENANCE: Only one vacuum tube. No moving parts except meter.

Doelcam

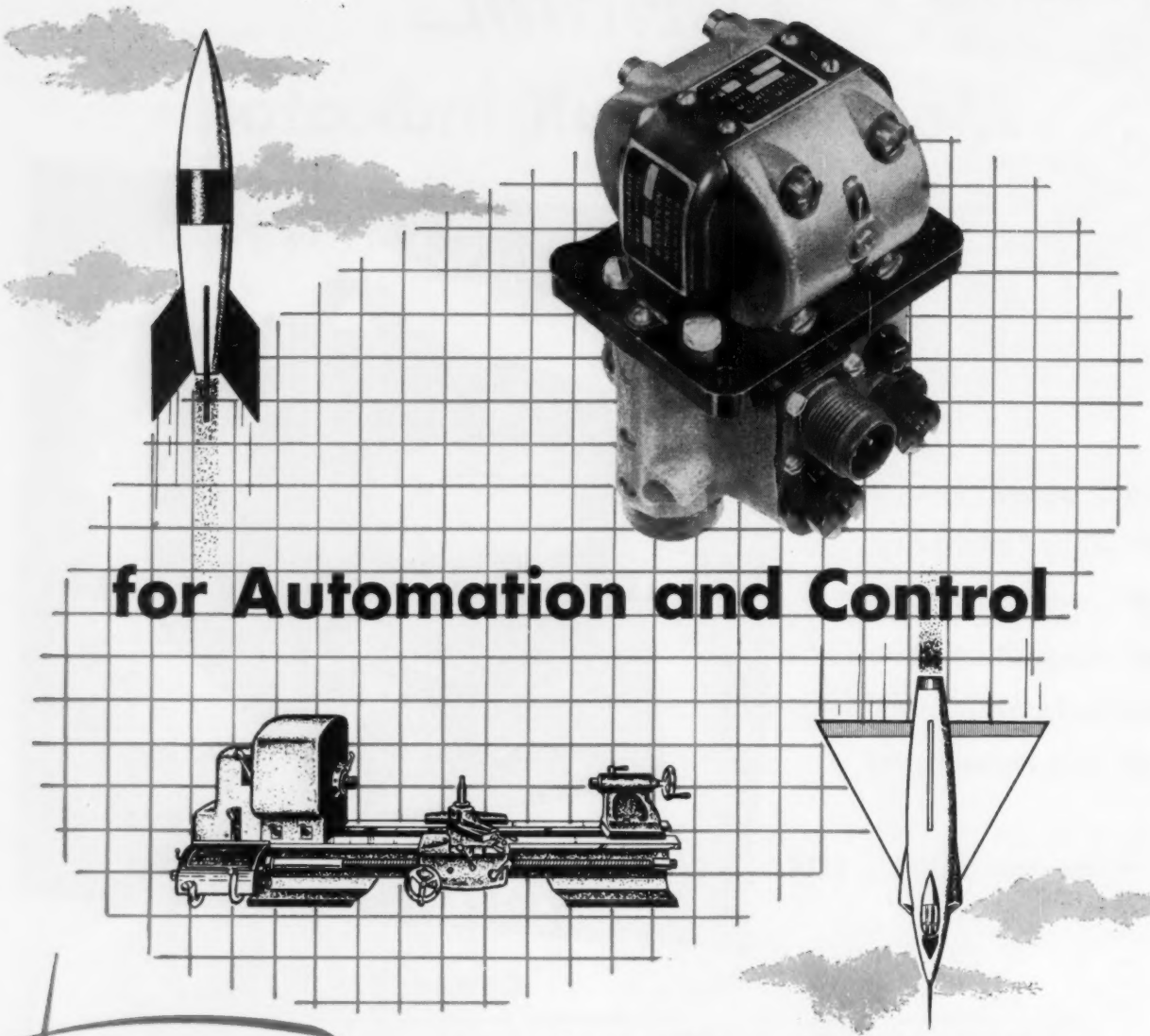
A DIVISION OF MINNEAPOLIS-HONEYWELL H HONEYWELL SOLDIERS FIELD ROAD BOSTON 35, MASS.

Instruments for Measurement and Control

Synchros • Gyros • Amplifiers • Microsyns • Servo Motors

For more information circle **18** on inquiry card.

MIDWESTERN'S proven Servovalves can solve your problems



for Automation and Control

products

- OSCILLOGRAPHS (LABORATORY AND FLIGHT TEST)
- MAGNETIC STRUCTURES
- GALVANOMETERS
- AMPLIFIERS
- HYDRAULIC SERVOVALVES
- TORQUE MOTORS
- SERVOAMPLIFIERS
- DATA REPEATERS
- WATERPROOF CONNECTORS
- GEOPHYSICAL EQUIPMENT

For servovalves—components, or complete systems for control or automation in ANY industry . . . Midwestern production facilities can help you solve your problems.

Write for Assistance with your Automation or Control problems

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MIDWESTERN INSTRUMENTS

41st and Sheridan Road — Tulsa, Oklahoma

For more information circle **19** on inquiry card.

HOW TO SOLVE THE *tough* NEEDLE VALVE PROBLEMS

Teflon-packed American Needle Valves "lick" the really tough meter manifold jobs — sour gas, wet gas, odorizing, chemical plant and refinery applications and other difficult and corrosive field services.

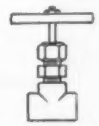
Precision machined valve bodies (stainless or carbon steel) are specially suited for welding. Stainless steel valve stems, centerless-ground for exact fit, are designed so that the valves can be repacked under pressure. Positively aligned valve seats are burnished for point-contact seating.

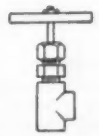
Every valve is hydrostatically tested. Standard valves are designrated for 5000 psi working pressure at 70°F. Valves are also available for higher pressures to 10,000 psi and can be furnished, with graphite impregnated asbestos packing, for temperatures above 450°F.

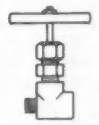
Write for Complete Specifications.

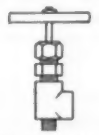
In actual tests, Teflon packing prevented gland leakage through 124,000 on-and-off cycles, without tightening the packing nut.

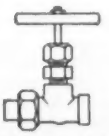
UNION BONNET
ANGLE PATTERN
(Female Ends)


SCREWED BONNET
STRAIGHT PATTERN
(Female Ends)


SCREWED BONNET
ANGLE PATTERN
(Female Ends)


SCREWED BONNET
STRAIGHT PATTERN
(Male End)


SCREWED BONNET
ANGLE PATTERN
(Male End)


SCREWED BONNET
STRAIGHT PATTERN
(Union End)

AMERICAN® METER COMPANY
INCORPORATED ESTABLISHED 1874

GENERAL SALES OFFICE: 1513 Race Street, Philadelphia
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IN CANADA: Canadian Meter Company, Limited
Hamilton, Ontario • Edmonton, Alberta

For more information circle **20** on inquiry card.

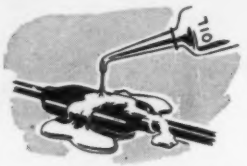
Partners in Production

Joy Electrical Connectors and Automatic Controls

What happens to Automation . . . when electrical connectors fail?

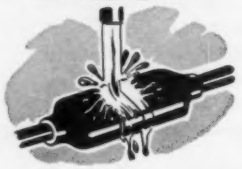
No automatic control system yet devised will keep machines running when an electrical plug or receptacle in their power feeder line or power control circuit *poops out.* That's why JOY's one-piece molded Neoprene connectors deserve your careful consideration. Factory wired and permanently molded to cord or cable, they provide many extra advantages that add up to a long life of dependable service under the most adverse operating conditions. (A few are listed below.) Available in a wide variety of designs with 1 through 16 contacts for 150 to 600 volt applications. **Joy Manufacturing Company, Oliver Building, Pittsburgh 22, Pa.** In Canada: *Joy Manufacturing Co. (Canada) Limited, Galt, Ontario.*

Oil-Sealed . . .
One-piece molded cable connector assembly protects conductors from oil and other external impurities. Face rings protect contacts from similar contamination, when connectors are engaged.



Distortion-Proof . . .
Factory molded as trim one-piece synthetic rubber jacketed units, JOY connectors cannot crack, will not shatter and are practically impossible to knock out of shape.

Moisture-Tight
JOY electrical connectors are absolutely moisture-tight from wiring juncture to face . . . and when connected even their contacts are protectively encased in a resilient housing.



CD 355.2

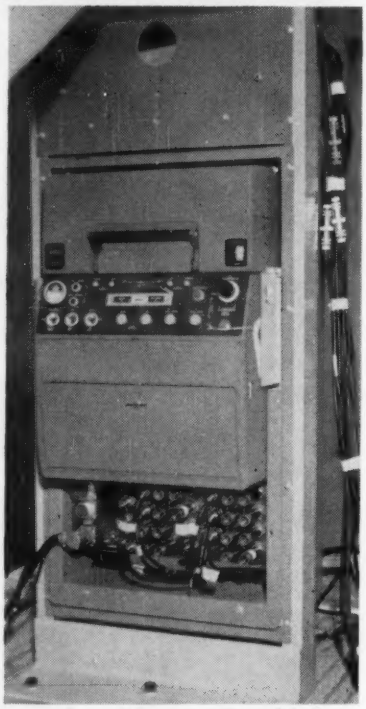
JOY
SOURCE OF INDUSTRY'S FAVORITE ELECTRICAL CONNECTORS SINCE '28

For more information circle **21** on inquiry card.

Oscillograph Road Test

PASADENA, CALIF.—Consolidated Engineering Corporation engineers wanted to test a new vibration-cushioning rack-mounting for one of the firm's large oscillographs. So they gave it a "road" test over some of the worst roads in Southern California. After a day-long test, pictured here, they found that neither chuck-holes nor railroad tracks caused any appreciable errors

in Consolidated's Type 5-119 recording oscillograph.



The test was unique because the oscillograph made a recording of its own vibration. Three CEC Vibration Pickups were mounted on the rack to test for vertical, lateral and longitudinal vibration. Three others were mounted on the braces holding the rack to the truck. For calibration, the six galvanometer traces were checked against static, properly damped galvanometers. As the maximum error on the record for the worst shock experienced was negligible, ground mobile use of multi-channel oscillographs is possible.

Heidelberg Conference on Automatic Control

WEST GERMANY.—The joint Committee for Automatic Control of the German Association of Electrical Engineers (VDE), and the German Engineers Society (VDI) is holding a Conference on Automatic Control in Heidelberg, September 24 thru 28, 1956. Cooperating is the Committee on Mathematics in Automatic Control of the Society for Applied Mathematics and Mechanics (GAMM). Original papers from American authors are

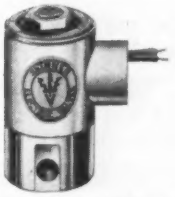
Continued on page 1814

OVER 100,000 VARIATIONS

It's a fact . . . Skinner V5 Valves are obtainable in more than 100,000 variations! The unique design of these rugged, low-cost valves makes them easily adaptable to countless applications throughout industry. They're built to withstand high voltages, extremes of temperature and constant energizing over a period of years, through millions of cycles. A vast variety of port locations and flow adjustments enables you to make valves conform to your equipment, rather than vice versa.

Skinner Valves are available with UL-approved Explosion-Proof construction, and with "Quick Exhaust" for extra-fast cylinder return.

If you have a solenoid valve problem, by all means call in a specially trained Skinner resident engineer. There's no obligation, and chances are you'll find your problem solved in a trice. *Write today for Skinner's new solenoid valve catalog.*



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SOLENOID

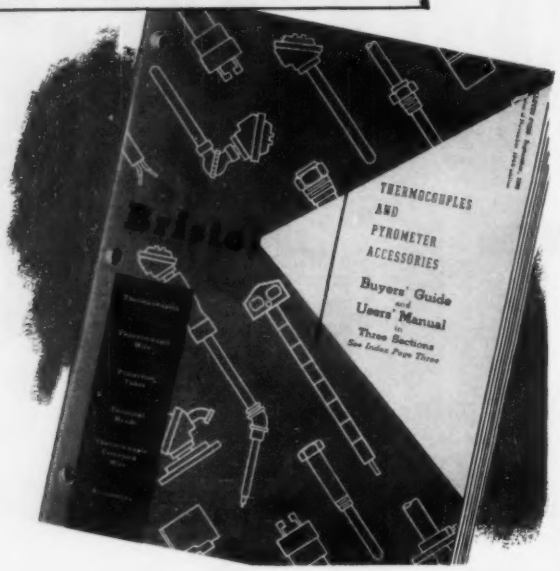
SKINNER ELECTRIC VALVES ®

116 Edgewood Avenue
New Britain, Conn.

WORLD-WIDE REPRESENTATION

For more information circle **22** on inquiry card.

WHAT'S NEW AT BRISTOL...



Don't be without this free pyrometer reference book!

If you use pyrometers, this fact-filled 56-page booklet is a "must". Its three sections tell you quickly everything you want to know about thermocouples and all other pyrometer accessories.

Chock-full of money-saving ideas, informative illustrations, charts, and detail drawings, this well-indexed book does these three jobs:

HELPS YOU SELECT THE RIGHT THERMOCOUPLE, wire, and protecting tube for every installation. Complete information on all thermocouples and radiation pyrometers, with installation suggestions.

HELPS YOU KEEP THERMOCOUPLES ON THE JOB. Complete, well-tabulated descriptions of replacement parts and accessories, with simple ordering instructions.

HELPS YOU GET QUICK, ACCURATE CALIBRATION DATA. Calibration tables for all commonly used thermocouples, in Centigrade and Fahrenheit scales. 4.18

Mail the coupon today for your free copy!

The Bristol Company
113 Bristol Road
Waterbury 20, Conn.

Gentlemen:

Send me a free copy of your pyrometer fact book.

Name_____

Firm_____

Address_____

City_____ Zone____ State_____

For more information circle **23** on inquiry card.

solicited and should be submitted to the Secretary of Verein Deutscher Electrotechniker (VDE) Osthofenplatz 6, Frankfurt a/Main, Western Germany, not later than April 1, 1956 upon registration prior to January 1, 1956. Preprints of all papers will be available.

The topic of the Conference will be "The Importance of Theory for Automatic Control Applications."

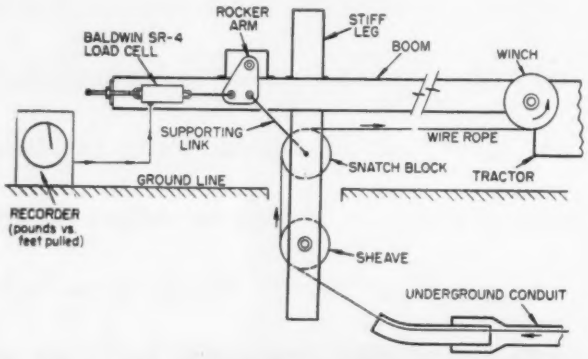
Subjects will include mathematical methods for solving linear and nonlinear control problems, also application of computers, optimum-control, and self-adjusting controllers.

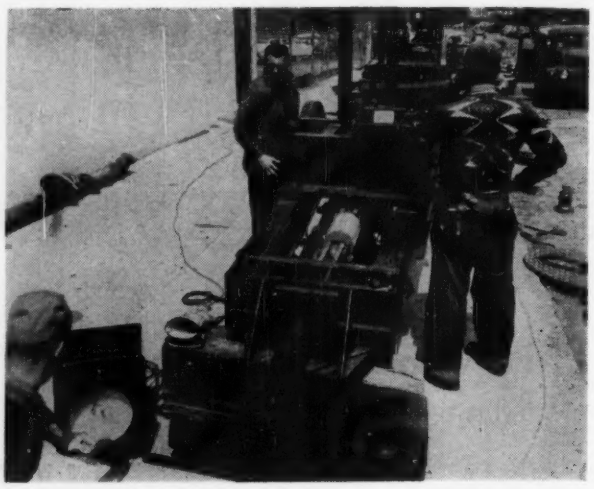
Cable-Pull Control

PHILA., PA.—The forces that are required to pull electrical cables through underground conduit are shown here being measured by a newly developed electrical method which provides a continuous record of pulling forces. The method is being used to study pulling techniques with the objectives being installation of longer lengths of cable and prevention of damage.

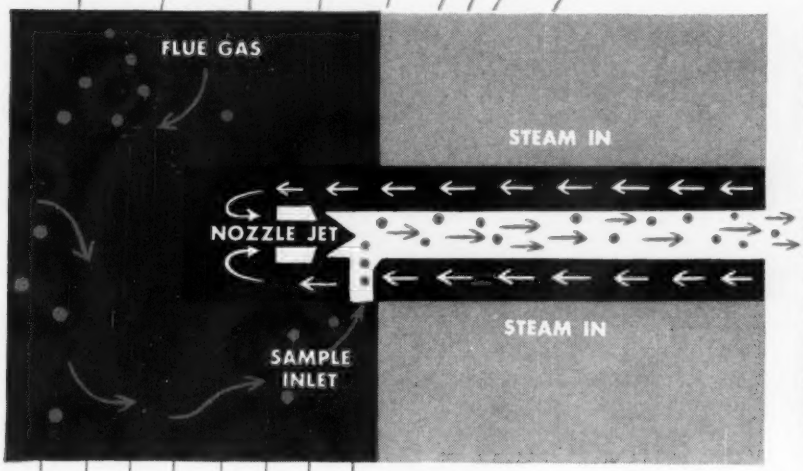
In a cable-pulling system developed by Philadelphia Electric Company, the winch drum on the cable-pulling tractor pulls wire rope over a snatch block which is supported by a link to a vertically suspended rocker arm attached to the boom. Horizontal movement of the arm is restrained by a Baldwin-Lima-Hamilton SR-4 load cell which is an electrical force transducer for transmitting load signals to a recording instrument. The recorder, a Foxboro instrument, was modified with a built-in electronic amplifier and bridge circuit for null-balance in

Continued on page 1819





NEW DIMENSIONS



in Gas Sampling

NEW SAMPLING SYSTEM OPERATES ON STEAM!

The new Hays Gaspirator* System is designed especially for difficult gas sampling problems involving high dust loading and high temperatures. It now permits accurate O_2 measurement, previously impossible in many applications.

This gas sampling system uses steam to obtain a continuous, clean sample. Suction which is created by the jet nozzle draws the sample in, where it is mixed with the steam. The steam is then condensed. Condensate and entrained solids drop down, and the sample is forced through the analyzer under pressure.

Hays, in the field of gas analysis for more than fifty years, developed the Gaspirator for use with their Magno-Therm Analyzer.

This analyzer, which operates on the paramagnetic principle, has for years been accepted as the leader in the field of O_2 measurement. Hundreds of companies are using the Magno-Therm and Hays electronic recorders very successfully in boiler plants and on process furnaces as a combustion guide, in regeneration of catalysts in refineries and in many other process applications.

For further details write for Bulletin 55-829-56.

*Patents pending.

THE **hays** CORPORATION

MICHIGAN CITY 8, INDIANA

Automatic Combustion Control • Varidraw Meters and Manual • Electronic Oxygen Recorders • CO2 Recorders Boiler Panels • Gas Analyzers • Combustion Test Sets Draft Gages • Electronic Flowmeters • Miniature Remote Indicators • Electronic Feed Water Controls

For more information circle **24** on inquiry card.

Baldwin SR-4 System indicates and continuously totalizes ore loads in the crane cab (above). The operator has a continual check on the load being carried by the clamshell.

At Alabama State Docks this Heyl & Patterson crane...

unloads ore faster by using SR-4® automatic weighing system

Baldwin's "Packaged Precision Measurement" can cut your ore handling costs. That's been proved at the Alabama State Docks, Mobile, Alabama. There a Heyl & Patterson unloading crane is using Baldwin SR-4 load cells and indicator to weigh electrically clamshell buckets of ore.

This Baldwin SR-4 automatic weighing system benefits this user three ways:

1. **Faster handling:** The bucket does not have to be stopped to determine weight since its weight is being measured by two 20,000 pound load cells in the sheave block. More ore can be handled by the unloading equipment each shift, reducing handling costs.
2. **Easy operation:** A large indicator dial in front of the operator tells him when to add the weight on the totalizing counter. The indicator totalized the weights measured by two distant SR-4 Load Cells and zeroes out all but net weight of ore.
3. **Low maintenance:** SR-4 Load Cells have no moving parts to wear out. They are sealed against air-borne dust. They are giving accurate, dependable service.

Baldwin SR-4 Load Cells can solve your weighing and force-measuring problems. Write for our *new* Bulletin 4301. It's loaded with detailed information on typical applications and instrumentation for these unique devices. It tells you how to use them for local or remote indication, recording, signaling or process control. Use coupon today!

Department 3215
Baldwin-Lima-Hamilton Corp.
Philadelphia 42, Pa.

(in Canada: Peacock Bros., Ltd., Montreal, Quebec)

☐ #4301 (SR-4 Load Cells and Load Beams)
☐ #4304 (SR-4 Crane Scales)

Name_____ Title_____

Company_____

Address_____

City_____ Zone___ State_____

BALDWIN BLH LIMA-HAMILTON

Eddystone Division
BALDWIN-LIMA-HAMILTON

For more information circle **25** on inquiry card.

Circle **26** on inquiry card.

Brush instrumentation can put the data in writing

Versatile Brush Recording Systems are ready for *tomorrow's* telemetering applications – and for your needs *today* in virtually all measurements. Here is why these instrumentation systems are preferred:

- They are the most flexible direct-writing recording systems available, providing you with a choice of ink and electric writing in the same units.
- They allow you to select the best chart speed for good signal reproduction and economy by providing the widest speed range available– 10″ per day to 10″ per second.
- You can change speed instantaneously from either local or remote locations. There is no interruption in recording because of the unique Brush electrically controlled chart drive.

In virtually any kind of measurements, you'll get the facts easier and faster with Brush equipment. Call your Brush representative or write for complete information.

Brush Recording Systems are used in telemetering and associated measurements by leading companies such as Boeing Airplane Company; Northrop Aircraft, Inc.; Convair; Cook Electric Co.; Republic Aviation Corp.

BRUSH ELECTRONICS COMPANY

INDUSTRIAL AND RESEARCH INSTRUMENTS
PIEZOELECTRIC MATERIALS • ACOUSTIC DEVICES
MAGNETIC RECORDING EQUIPMENT AND COMPONENTS

BRUSH 6 ELECTRONICS

Division of Clevite Corporation

LOOK TO BRUSH FOR YOUR MEASUREMENTS

ELECTRICAL

MECHANICAL

OPTICAL

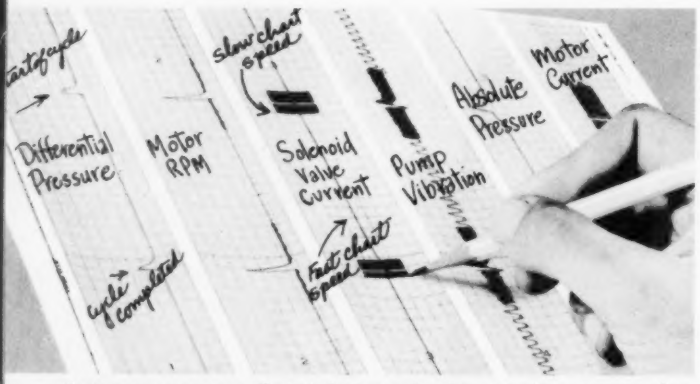
THERMAL

ACOUSTICAL

NUCLEAR

NEW IDEAS IN MEASUREMENT FROM BRUSH

More and More Engineers are checking performance of equipment in the field thanks to new portable instruments by Brush. Here operating data is recorded from vibration pickups on a tractor and on a driver's back. Brush Portable Instruments are lightweight, easy to use and designed for rugged use. Ideal for recording stress, strain, force, vibration, torque, pressure, electrical variables and other physical characteristics.



Gets more answers. Typical chart recording from a test on a pump system shows the wealth of information obtained by Brush Systems. Charts can be driven at many different speeds to obtain optimum clarity and economy. Chart drive is electrically controlled, thus speed can be changed instantaneously from local or remote locations.

Helps in "sound" design. Where sound or vibration is a problem you can obtain complete vital data with the new Brush Third-Octave Spectrum Recorder, coupled with either the measurement microphone or broad band accelerometer. This system provides a complete frequency and noise level analysis in third-octave bands from 35 cycles to 18,000 cycles per second and automatically plots entire analysis data.

BRUSH ELECTRONICS COMPANY

INDUSTRIAL AND RESEARCH INSTRUMENTS
PIEZOELECTRIC MATERIALS • ACOUSTIC DEVICES
MAGNETIC RECORDING EQUIPMENT AND COMPONENTS

BRUSH ELECTRONICS

Division of Clevite Corporation

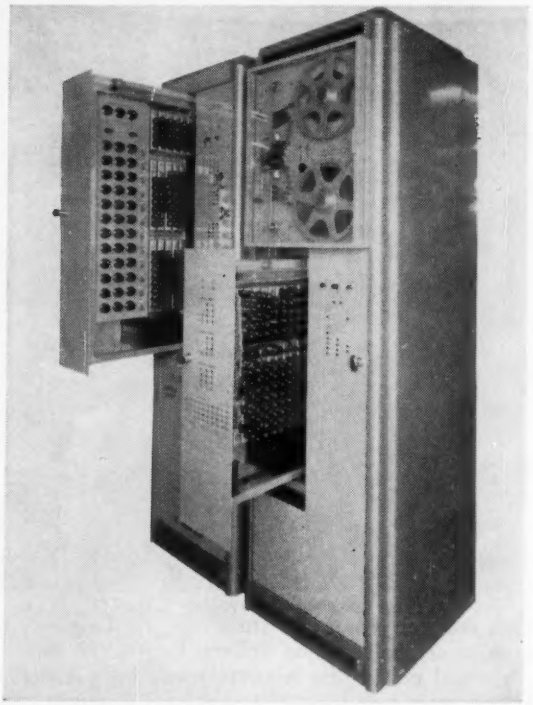
Call BRUSH for the answer!

For help in your measurement problems, call your nearby Brush representative, or write Brush Electronics Company, Department 88, 3405 Perkins Avenue, Cleveland 14, Ohio. Your request will receive prompt attention!

force measurement, and with selsyn motor and 60:1 gear reduction unit to drive the round chart in order to show feet of pull versus pulling tension. This motor is controlled by a selsyn transmitter connected to a foot counter wheel so mounted that it is held in contact with the wire rope. The force-measuring system is operated by 115-volt A.C. For field operation this is provided by a 750-watt generator driven by a small gasoline engine. A maximum pulling force of about 20,000 lb. was observed for a maximum length of 3300 ft. of cable by Philadelphia Electric Company. Pulling speeds were normally between 20 and 35 ft. per minute, as determined by timing recorded lengths being pulled. The charts obtained through this application of resistance-wire strain gages provide a graphic record of instantaneous loads, making possible a better evaluation of the factors contributing to pulling tensions.

Doppler Data Translator

ABERDEEN, MD.—A new development in data handling equipment is the Doppler Data Translator, Model 3154, developed for the Ballistic Research Laboratories, Aberdeen Proving Ground, Md., by Potter Instrument Co., Great Neck, N. Y., L. I. It is used to accept doppler



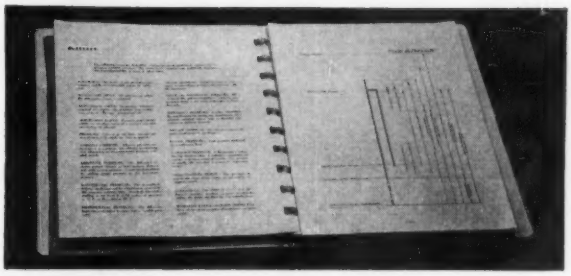
radar data and associated interpolation and time code signals from a cylindrical magnetic tape, and to read and code this information onto a digital data magnetic tape suitable for use by a high-speed electronic computer. The Doppler Data Translator can be utilized where velocity of a missile or other aircraft is desired in digital form for computations.

Nuclear Research Laboratory

NEW YORK, N. Y.—Eight of the nation's leading industrial companies plan to build and operate in the New York area one of the first privately owned nuclear reactors

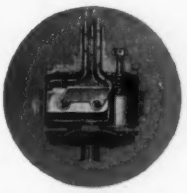
Continued on page 1820

FREE

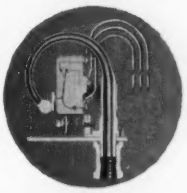


THE ONLY
COMPLETE HANDBOOK
ON PRESSURE & VACUUM SWITCHES

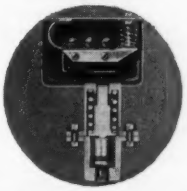
As an aid in planning the vital link between your electric and hydraulic circuits, this manual contains a glossary of terms and a schematic demonstration of operating characteristics. Functions and methods are described in detail and liberally clarified with diagrams and illustrations, including symbols for circuit detailing and specification purposes. To provide the means for proper selection of a pressure switch for your specific application, a simple step by step selection chart has been developed helping you to organize your requirements in their relative order. Finally a complete run-down, illustration and tabulation of all the detail features leading to the unit that answers your specific control problem. You couldn't buy a comparable handbook.



FOR EXTREME ACCURACY,
Diaphragm and Bourdon Tube Switches
Vacuum to 12,000 P.S.I.



FOR EXTREMELY LONG LIFE,
Piston Switches, Low Settings — High Proof Pressures to 15,000 P.S.I.



FOR HAZARDOUS LOCATIONS
Explosion-Proof Models

ALL SWITCHES operate in any position, are not sensitive to vibration.

BARKSDALE VALVES
PRESSURE SWITCH DIVISION
5125 Alcoa Avenue, Los Angeles 58, California

Please send a copy of the above described *Free* handbook 4M.

NAME _____ TITLE _____

COMPANY _____

ADDRESS _____

CITY _____ ZONE _____ STATE _____

For more information circle **27** on inquiry card.

←——Circle **26** on inquiry card.

BORG MICRODIAL

DIRECT READING THROUGH 3600° TO A DIGITAL ACCURACY OF 1 PART IN 1000.

FITS ANY MULTI-TURN DEVICE HAND OR SERVO OPERATED

The new direct reading Borg Microdial Model 1301 practically eliminates human error because it was designed for forced fast reading. Laboratory, production and processing controls become more accurate when clear, sharp, figures on the specially designed Borg Counter are observed through the focal-point window. Borg Counter figures are seen against a dull black background to provide maximum contrast for instant perception under difficult reading conditions.

The specially designed Borg Counter in the Model 1301 Borg Microdial reads from 000 to 999 to 000 in 3600 degrees of continuous rotation with no stops. Maximum recommended operating speed is 10,000 counts per minute (100 rpm).

Designed for military application, it has a built-in dust shield and clear-vision, wide-angle window for accurate reading from almost any position in front of the dial.

The Model 1301 Borg Microdial is compact. It measures only 1-3/4″ in diameter and 1-5/8″ in height and occupies no more panel space than the Micropot it controls.

WRITE FOR CATALOG SHEET BED-A31

BORG EQUIPMENT DIVISION
THE GEORGE W. BORG CORPORATION
JANESVILLE, WISCONSIN

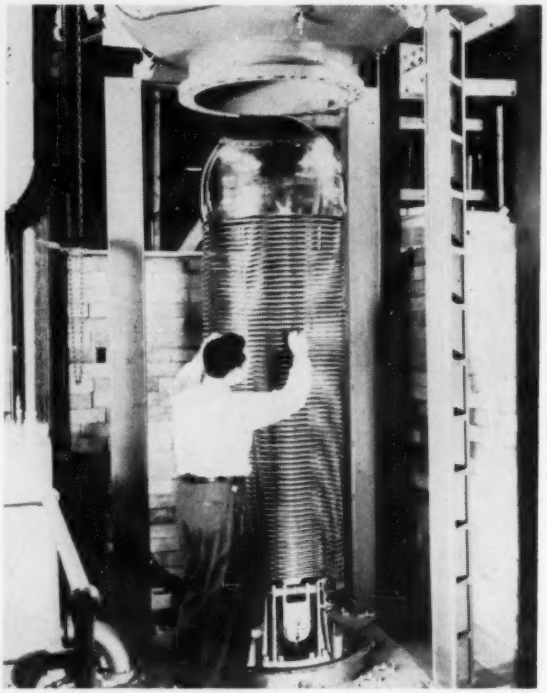
For more information circle **28** on inquiry card.

for research in industrial and humanitarian fields, it was announced by AFM Atomics, Inc., a subsidiary of American Machine & Foundry Co. Companies participating include AFM Atomics, American Tobacco Co., Continental Can Co., Corning Glass Works, International Nickel Co., Chas. Pfizer & Co., Inc., Socony Mobil Oil Co., Inc., and the United States Rubber Co. Other companies are expected to announce their participation.

The Industrial Reactor Laboratories, as the facility will be called, will be located on a 250-acre tract within commuting distance of New York. Cost will be between 1.5 and 2 million. Reactor will be of the "swimming pool" type using uranium fuel surrounded by water serving as moderator, cooler and shield.

New Radiation Lab

PITTSBURGH, PA.—Gulf Oil Corp. announces plans for a nuclear science laboratory to be located at the com-



pany's research center in Harmarville, Pa. Cost may be in excess of one-half million dollars.

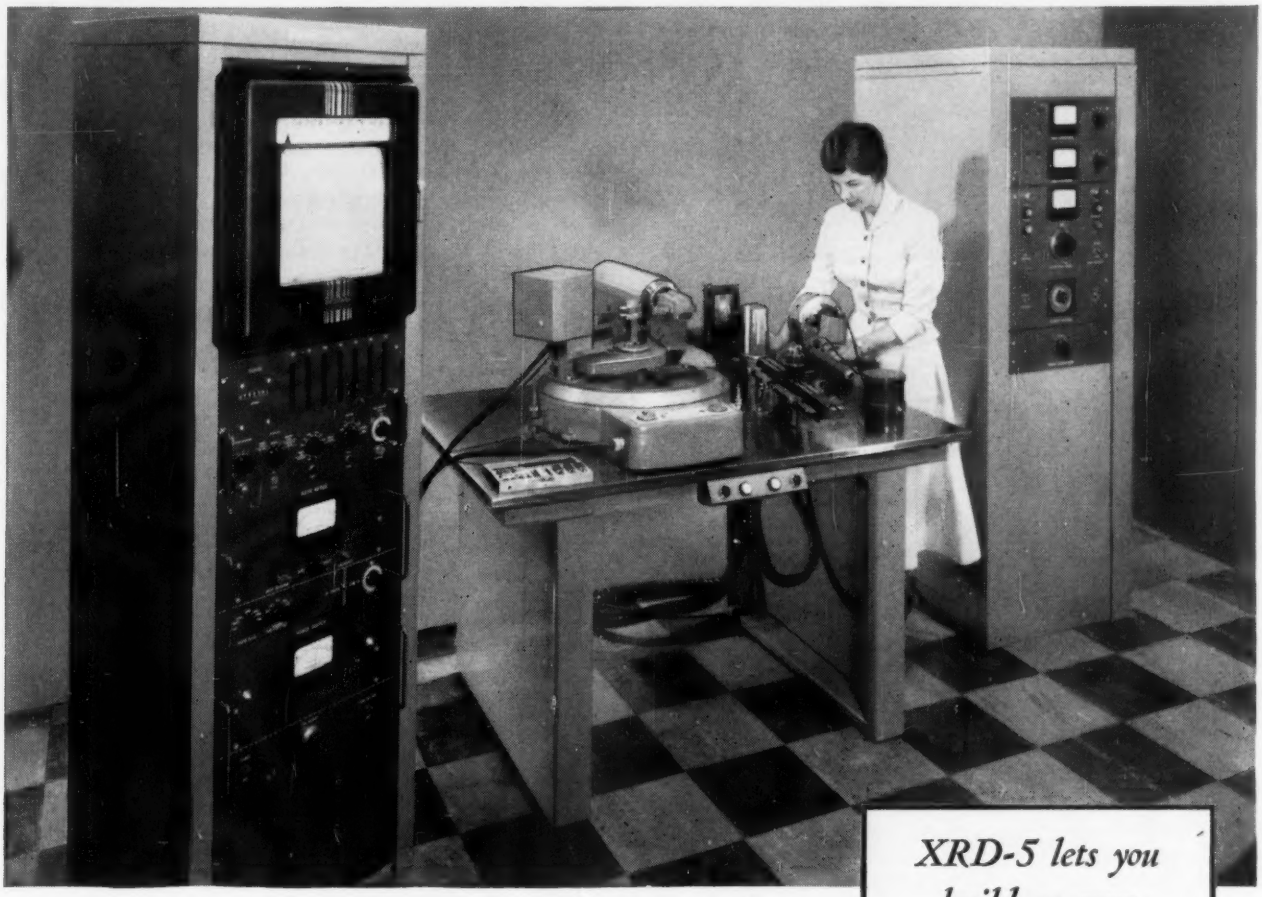
Principal unit in the laboratory will be a giant 3,000-000-volt atom smasher (Van de Graaf Particle Accelerator) which is being built by High Voltage Engineering Corp., Cambridge, Mass.

Calibration Area Control

OKLAHOMA CITY, OKLA.—Calibration of gages, micrometers, indicators, templates and other instruments used in repair of jet engines and other Air Material Command shop operations is performed at the Oklahoma City Air Material Area Headquarters, Tinker Air Force Base, which administers a 13-state area. The gages are periodically checked against prime masters at the AMC

Continued on page 1822

General Electric announces a versatile *new x-ray diffraction unit*



Featuring one or two tube operation

Here's the latest advance in x-ray diffraction apparatus. It's the new General Electric XRD-5, the unit that's designed with special care to fit any analysis program.

As shown in the box at right — you can start with a simple film set-up. Build up facilities as needed. Possibilities include: film technics for up to six instruments at a time, simultaneous film and direct measurement technics on two different tubes, and fluorescence analysis.

Whatever your analysis requirements — research, raw materials or quality control — this General Electric diffraction unit can be adapted to your exact needs. Get full information from your G-E x-ray representative, or write X-Ray Department, General Electric Company, Milwaukee 1, Wis., for Pub.BL-114.

XRD-5 lets you build as your needs grow

1. Basic XRD-5 includes simple table, one tube, camera and camera tracks, one kv panel, one ma panel, one timer panel, with choice of three cooling methods. You are equipped for film technics.
2. Add a tube unit, another ma panel, a tube selector panel — and you're equipped for two-tube film technic.
3. Add a spectrogoniometer, a horizontal tube support, a direct measurement attachment (No. 2 SPG detector that includes power supply, linear and logarithmic ratemeter, 8-decade scaler) — and you're equipped for simultaneous film and direct measurement technics.
4. Add a spectrometer — and you're fully equipped for fluorescence analysis.
5. Add a helium tunnel assembly — and you're equipped for fluorescent detection of any material down to Atomic No. 15.

Progress Is Our Most Important Product

GENERAL ELECTRIC

For more information circle **29** on inquiry card.

Your plant is in this picture

It might as well be YOUR plant, for in it, Kirk & Blum can bring your drawings to life . . . with substantial savings for you in costs and capital investments.

Kirk & Blum offers complete facilities for the fabrication of sheet and plate to ½" thickness—and light structurals. We specialize in aluminum, monel, stainless and other alloy fabrication.

- Weldments
- Components
- Assemblies
- Sub-Assemblies
- Cabinets
- Housings
- Enclosures

In the modern 150,000 sq. ft. Kirk & Blum plant is to be found the latest metalworking equipment available, operated by skilled sheet metal craftsmen. Overhead cranes, to 25 ton capacity, serve entire assembly areas and interior rail siding. A new warehouse contains extensive inventories of materials. Coordinated for speed, versatility and accuracy, these facilities assure successful and economical completion of your products.

THE KIRK & BLUM MFG. CO.
3111 FORRER STREET
CINCINNATI 9, OHIO
Established 1907

KIRK & BLUM
SHEET METAL FABRICATION

For more information circle 30 on inquiry card.

headquarters at Wright-Patterson Air Force Base, Dayton, Ohio, or at the National Bureau of Standards in Washington. Under this master gage program of the Air Force, the checked and corrected gages then are returned to serve as masters in the 13-state area.

Calibration is done in a 1,900-square-foot master gage room at Tinker. The area temperature is held to 68°F, ± 1°. Moisture content likewise is controlled by a Kathabar chemical-type humidity conditioner with the relative humidity for this temperature held between 45 and 50%. Many of the instruments used at Tinker are moisture sensitive, and would give inaccurate readings if not protected against moisture.

The air in the master gage room likewise must be kept clear of dust, to maintain the required precision. An electronic pricipitator keeps the dust factor at 5% maximum.

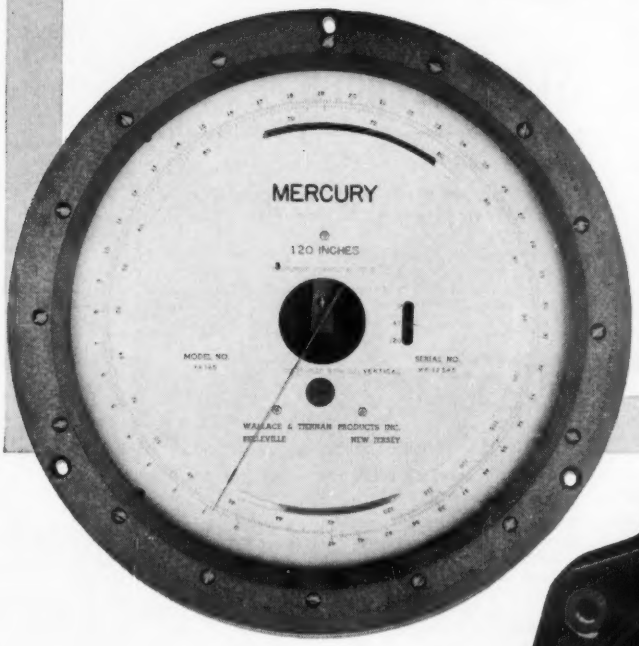
News Bits

FORD MOTOR COMPANY has installed 2 new direct-reading "Spectrometers" (spectrometers of Baird Associates, designed for analysis of iron and steel compositions) in its Dearborn Iron Foundry—**WILMINGTON SECTION,** ISA, announces two courses (electronics and frequency-response techniques) to be given this year; Tom Vic Roy will teach the electronics course—**DR. ANDREW TIMNICK** of the Michigan State University chemistry Department has developed a sensitive "high-frequency titrimeter" operating in the 100-Mc range for precision analyses of high-concentration solutions—**A MESH SCREEN** of 300 lines/inch has been successfully placed on a negative by the Industrial Division of W. & L. E. Gurley, Troy, N. Y.; mesh contains 200,000 accurately spaced holes so small that a human hair cannot pass through them—**PEACETIME USES OF NUCLEAR ENERGY** are being evaluated in a study being carried out by University of Minnesota, Northern States Power, Minneapolis-Honeywell, and General Mills—**BANK OF AMERICA** and Stanford Research Institute announce joint development of "the biggest advance in bank-account bookkeeping in the history of banking," a computing machine called ERMA (Electronic Recording Machine, Accounting)—**FIRST APPLICATION** of solar power to telephone lines occurred 10 A.M., Oct. 4, 1955, when Bell Telephones Laboratories switched solar power into rural telephone system—**REACTOR "CRITICAL" FACILITY** will be built in Dutchess County, N. Y., by Nuclear Development Corporation of America—**UNIVAC SYSTEM** with central electronic file computer will be installed in the Executive Office Building of the Carborundum Company, Niagara Falls, N. Y.—**CURTISS-WRIGHT CORPORATION** of Wood-Ridge, N. J. has been granted a license to manufacture printed electrical circuits by the Technographic Process—**AEC** has invited proposals for the design, construction, and operation of experimental nuclear power plants in ranges of 5-10, 10-20, and 20-40 megawatts—**BURROUGHS CORPORATION** Detroit 32, Mich., has developed a thickness gage with both aural and visual indication of thickness and limits, thus enabling the blind to test precision parts—**QUARTZ CLOCKS** at the National Physical Laboratory, England, were checked recently with an atomic standard; they now keep time to 1 second in 30 years, but laboratory hopes for 1 sec-

PRECISION PRESSURE MEASUREMENT

of Gauge Pressure, Vacuum or Differential Pressure

Precision Dial Manometer Type FA-145



Accuracy:
1 part in 1000 over full scale.
Sensitivity:
1 part in 10,000 in *all* ranges.
Ranges:
0 to 120 inches of water (min.)
0 to 250 inches of mercury (max.)
Other intermediate ranges available.
Scale Length:
45 inches.
Dial Diameter:
8½ inches.

Precision Low Pressure Gauge Type FA-141

Accuracy:
1 part in 300 over full scale.
Sensitivity:
1 part in 500 in *all* ranges.
Ranges:
0 to 10 inches of water (min.)
0 to 400 inches of water (max.)
Other intermediate ranges available.
Scale Length:
7 or 16 inches.
Dial Diameter:
2¾ or 6 inches.

WALLACE & TIERNAN
INCORPORATED
PRECISION INSTRUMENTS AND ELECTRICAL MECHANISMS
25 MAIN ST., BELLEVILLE 9, N. J.
In Canada: Wallace & Tiernan, Ltd., Toronto

For additional data, write for Publication TP-30-A and TP-27-A

A-101

For more information circle **31** on inquiry card.

Precise

TEMPERATURE MEASUREMENTS

. . . with the Rubicon

MUELLER BRIDGE

A highly accurate and specialized form of the Wheatstone bridge designed expressly for precise resistance thermometry with three- or four-lead thermometers and for the measurement of other similar resistors within its range.

- Wide range: 0 to 141.1110 ohms in increments of 0.0001 ohm
- Unity ratio with provision for convenient checking and precise adjustment of ratio arms
- Built-in mercury commutator for lead resistance compensation
- Sub-panel switch construction
- Built-in plug and block assembly for conveniently checking ratio, bridge zero and thermometer resistance with no disturbance of external bridge connections

Described in Bulletin 100

. . . with the Rubicon

PORTABLE PRECISION POTENTIOMETER

A two-dial instrument of exceptional accuracy and sensitivity.

- High-sensitivity, sturdy, built-in Pointerlite galvanometer —permits balancing to within 2 microvolts in low resistance circuits
- Completely self-contained assembly—no external accessories except the thermocouple circuit
- Two ranges —0 to 16.1 and 0 to 161 millivolts—readable to within 2 and 20 microvolts respectively
- Sturdy, compact construction for long dependable service

Described in Bulletin 270

RUBICON COMPANY

Electrical Instrument Makers

3755 Ridge Avenue Philadelphia 32, Pa.

For more information circle **32** on inquiry card.

ond in 300 years—**SWITCH** producing 10,000 contact closures/second was described at National Electronics Conference, Chicago. Stream of mercury from spinning nozzle strikes inside of a thin metal cylinder; deformation of metal makes contact with successive switch elements behind cylinder. Switch was developed at Battelle memorial Institute, Columbus 1, Ohio.—$1,000,000 **ALTITUDE TEST CHAMBER** of Dougles Aircraft Company, Tulsa Div., has $140,000 instrumentation system furnished by Fischer & Porter Co., Hatboro, Pa.—**ELEVATORS** for TV towers is new development, as is elevator control system. Union Switch & Signal Div., Westinghouse, has installed four with control based on low-frequency carrier wave on a single, 3-conductor cable.—**CONVERSION** of a standard electric typewriter to an automatic data-reduction readout device has been announced by Fischer & Porter Company, Hatboro, Pa.

Stock Report . . . . INSTRUMENTS and AUTOMATION

The following prices and price ranges are supplied by Bache & Co., 36 Wall Street, New York 5, New York

New York Stock Exchange:

Security	Price Range for Year Thru September 30 High	Low	As of September 30, Last
Aeroquip Corp.	17 1/2	8 1/2	14
American Chain & Cable	46 3/8	35 1/2	44
American Mach. & F.	35 7/8	24	25 5/8
American Mach. & M.	41 3/8	27 1/2	33 7/8
American Optical	53 1/4	39 1/8	45
Bell & Howell	42 1/4	30 1/2	37 1/2 - 38 1/2 (1)
Bendix Aviation	59 1/2	45 3/4	48 1/2
Bulova Watch (new)	25 3/8	23	23
Burroughs	34 1/4	22 7/8	27 1/8
Clevite	25 3/8	20 3/4	22 1/4
Dobeckmun	38 7/8	30 1/4	32 1/2
Gamewell	39	31 1/4	32 1/2 - 33 (1)
General Inst.	13	8 1/2	8 7/8
General Prec.	71 1/2	40 1/8	40 5/8
General Time	39 3/4	33 1/2	34 7/8
Hamilton Watch	25 1/4	18 1/2	18 1/2 - 19 (1)
Int. Business Mach.	450	349	397
Minneapolis-Hon.	70	53	56 7/8
National Cash Reg.	47	36 1/8	36 3/4
Radio Corp.	55 3/8	36 3/4	45 1/8
Raytheon	25 3/4	13 7/8	15 3/4
Robertshaw-F.	33 5/8	26 1/2	29 1/8
Sangamo Electric	30 3/8	26	26 3/4
Sperry Rand	29 5/8	21 1/4	23 3/8
Square D	52	41	42
L. S. Starrett	50	40 3/4	42 1/2
Sylvania Elec.	49 7/8	41	45 1/2
Telautograph	37 1/2	25 1/2	29 1/2
Texas Inst.	16 7/8	10 1/4	11 1/4
Underwood	43 1/8	33	36 5/8

(1) Bid - Ask price, no sale.

American Stock Exchange:

Security	Price Range for Year Thru September 30 High	Low	As of September 30, Last
Air Assoc.	12 3/4	8 3/4	9
American Meter	40	32 5/8	34 - 34 1/2 (1)
Beckman Inst.	26 7/8	19 3/8	23 3/4
Benrus Watch	10 7/8	9 5/8	9 7/8
Breeze Corp.	9 3/8	5 3/4	7 3/4
Consolidated Eng.	31 1/4	21 1/4	21 5/8
DuMont Labs.	17 1/8	13 1/4	14 1/2
ElectroData	17 7/8	10 3/8	12 1/4
Fairchild C. & I.	37 1/4	22 1/2	23
Int'l Resistance	12 3/8	5	9
Lear Inc.	13 3/8	7 3/8	8
Nat'l Res. Corp.	33 1/4	19 3/4	20
Neptune Meter	28 1/8	21	26
New Haven Clock	4 1/8	2 1/2	2 7/8
Norden-Ketay	19 1/2	11 1/2	12 5/8
Pneumatic Scale	31	27 1/2	27 1/2 - 29 (1)
Servomechanisms	13 3/8	8 1/4	9
Wallace & Tiernan	26 7/8	20 3/8	20 3/8
Waltham Watch	2 7/8	1 3/8	1 7/8

(1) Bid - Ask price, no sale.

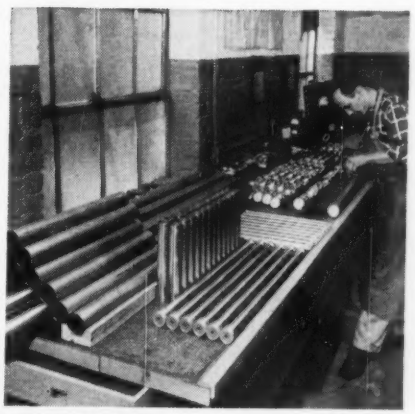
SUPERIOR TUBING acts as a temperature and mechanical handling shield for delicate sub-surface, radioactive logging instruments.

SMOOTH SURFACES, CLOSE TOLERANCES, LIGHT WEIGHT: REASONS WHY SUPERIOR TUBING IS USED TO HOUSE THESE DELICATE WELL SURVEYING INSTRUMENTS

Well Surveys of Tulsa, Okla., purchases Superior Seamless Type 304 Stainless Tubing in large OD, light wall sizes and in 63 in. lengths. Into these tubes, which in the finished state vary from 28 to 31 in., radioactive well-logging instruments are inserted—instruments so delicate that stray electrical waves or gases leaking into the casing may throw them off.

For that reason, the tubing is supplied in the "as drawn" condition, with a smooth surface that has a high radiation factor. Stainless is specified because plated material used in the past flaked off and short-circuited the instruments. The thin wall size (2.098" x .018" wall) is important; first, because of weight and, second, because of the close fit demanded. After the instruments are inserted, the tubing—closed by spinning—goes into an outer housing which must withstand pressures of 20,000 psi.

Whatever you want tubing for—an instrument housing, hypodermic needle, radio antenna, or heat exchanger—you'll find that the high quality of Superior tubing saves you time, money and production headaches. Send for your free copy of Bulletin 40—*A Guide to the Selection and Application of Superior Tubing*. SUPERIOR TUBE COMPANY, 1968 Germantown Ave., Norristown, Pa. *On the West Coast:* Pacific Tube Co., 1968 Smithway St., Los Angeles 22, Calif.



PRE-TESTING an assembly before it is inserted into the Superior tube.

Superior Tube

The big name in small tubing

All analyses .010" to ⅝" OD
Certain analyses in light walls up to 2½" OD

For more information circle **33** on inquiry card.

for **LOW-DISTORTION**
amplification
of **WIDE-BAND**
signals . . . use **SIE**
DIRECT-COUPLED
AMPLIFIERS

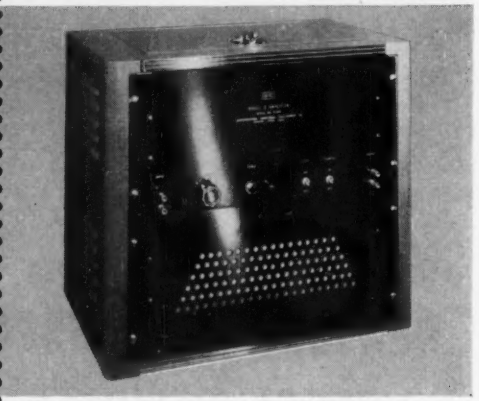
When your signals include frequencies from below 1 cps to above the audio range, a true direct-coupled amplifier gives the FLATTEST response over the WIDEST range with the LOWEST noise, distortion, and phase shift.

For voltage gain from transducers of all kinds, use the Model D-1. It will drive a 'scope, direct-writer, oscillograph, or magnetic recorder.

SIE MODEL D-I
Direct Coupled Amplifier

Input Impedance: 10 megohms or open grid, single ended or differential.
Noise: Less than 10 microvolts, wide-band.
Gain: 80,000, ± 1db, 0 to 50 kc.
1,000, ± 1db, 0 to 120 kc.
Drift: Less than 3 millivolts per hour, referred to input.
Maximum Output Signal: 80 volts into high impedance, 25 ma. into 1000 ohms. (Distortion less than 1%)

Price: **$515**



For power gain — to drive Helmholtz coils, servo motors, or small shakers — use the Model B.

SIE MODEL B
Direct Coupled Amplifier

Input Impedance: 500,000 ohms.
Voltage Gain: 2.5. *Power Gain:* 30,000.
Power Output: 6 watts into 100 ohms.
Frequency Response: 0 to 20,000 cps ± 1 db.
Output: 25 volts RMS at 250 milliamperes.

Price: **$575**

You can use the D-1 to drive the B — they rack-mount together perfectly!

SOUTHWESTERN INDUSTRIAL ELECTRONICS COMPANY

SIE

Industrial Instruments Division

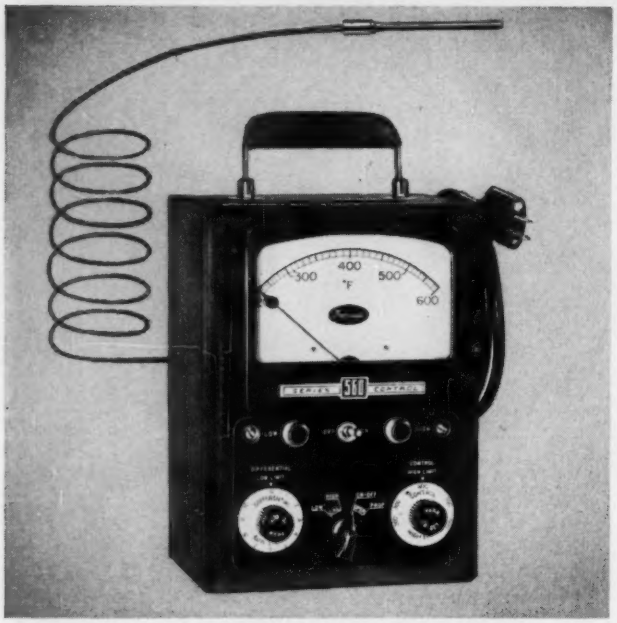
P. O. BOX 13058 • 2831 POST OAK ROAD • HOUSTON 19, TEXAS

For more information circle **34** on inquiry card.

OUT
IN
wherever precise flow
measurement is critical . . .
Potter TURBINE TYPE FLOWMETER
ACCURATE, DEPENDABLE POTTER FLOWMETERS are being specified by more and more chemical processors each year for jobs that demand high reliability, high precision, low maintenance, extreme control precision. Available in sizes from ⅛" to 6" units, they measure caustics, acids, corrosives, unstable compounds, suspensions, super-refined liquids and other hard-to-handle liquids at temperatures up to 1200°F and at pressures to 35,000 psi. Easily incorporated into complex control systems because of their linear output, Potter sensing units produce a signal that can be telemetered, fed into digital information handling systems, or measured directly to indicate or control flow rate or total flow.
Find out how this unique approach to flow measurement can help solve your flow-control problems. Write for Bulletin S-1.
POTTER AERONAUTICAL COMPANY • Route 22 • Union, N. J. • Phone MUrdock 6-3010
Makers of "Potter Engineered" products

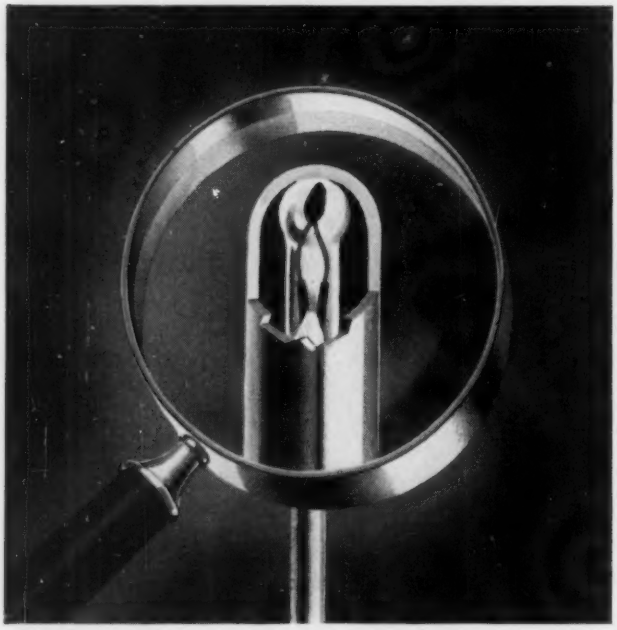
For more information circle **35** on inquiry card.

Which of these two instruments provides the temperature control accuracy you need?

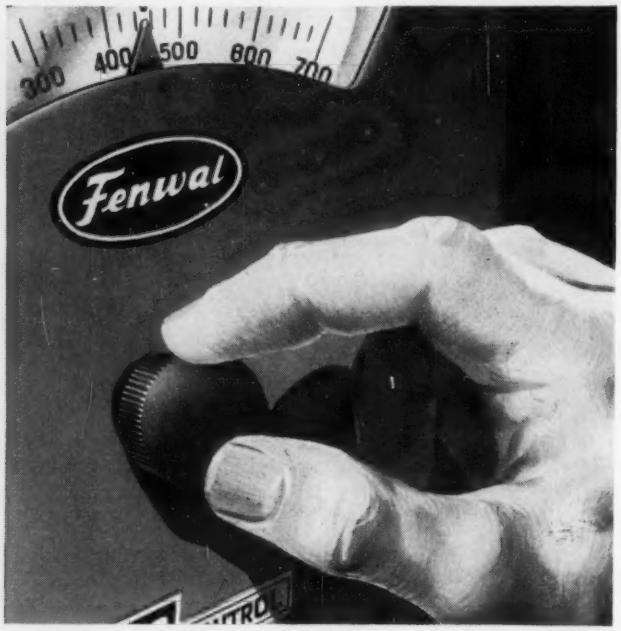


1. IT'S ELECTRONIC! The new Series 560 applies the thermistor principle in temperature indicator controls with heretofore unattainable accuracy over a scale range of 200° to 600°F. It's the *only* instrument that provides the three major control modes — (1) on-off (2) proportional (3) adjustable differential — all at the flip of a switch. Wide range of use for general laboratory, processing, molding or packaging applications.

2. IT'S MECHANICAL! The new Series 540 indicating controller combines low cost with high accuracy over a temperature range of 100° to 700°F. Temperature changes are transmitted by a bulb and bellows to an indicator control. Instrument features on-off control . . . adjustable differential . . . ambient compensation. May be flush or surface mounted. Capacity of 15 amps at 115 volts.



3. SIMPLICITY ITSELF is secret of Fenwal's Series 560 — accuracy, sensitivity and ruggedness. The thermistor's high resistance change permits operation with any length of lead wire up to 200 feet without affecting signal strength or accuracy. Thermistor is hermetically sealed in glass for stability; encased in stainless steel for ruggedness. No complex circuitry; maintenance is easy.



4. EASY "SET" AND "CHECK" OPERATION is a feature of Fenwal's Series 540 which is accurate to within 2% over the 100° to 700°F range, including the effects of ambient temperatures. Send for FREE NEW BULLETINS, MC122 on the Series 540, MC123 on the Series 560. Both contain full data you should have. Write to **Fenwal Incorporated, 3611 Pleasant St., Ashland, Mass.**

Fenwal Controls Temperature... *Precisely*

For more information circle **36** on inquiry card.

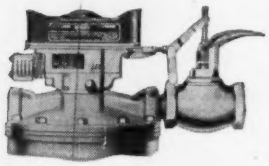
BOWSER
ESTABLISHED 1885

Automated

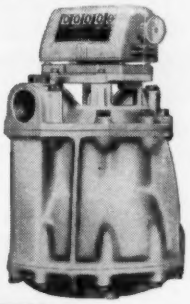
liquid handling is not new

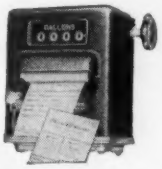
FLOW INDICATORS AND CONTROLS

Bowser's many years of experience are yours when you consider improved liquid-handling facilities for your operation. Here are examples of equipment applicable for automatic processing or production of industrial liquids . . . perhaps your product . . .



Optional repeating meter dial delivers predetermined quantities automatically.





Optional recording printer mounts on meter. Prints quantity of liquid metered.

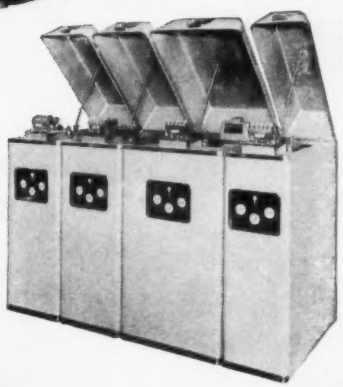
XACTO METERS

There is a Bowser Meter for nearly every product and application. Xacto Meters are standard in most industries. Broad capacity range. Choice of many dials and metal construction. Only a few are shown at left.

FILTERS

EXPENDABLE CARTRIDGE TYPE

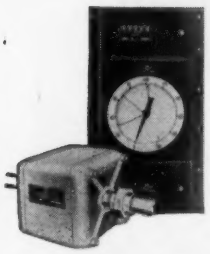
A wide range of Bowser filters and dehydrators is available for both oil and aqueous liquids in batch and continuous operations. Cartridge-type for oils is shown at left.



BLENDING SYSTEM

Accurately blends two or more liquids in desired proportions for continuous or intermittent line production. Each ingredient is metered and recorded for uniformity in closed, piped system. Blends oils, beverages, chemicals, liquid foods, etc.

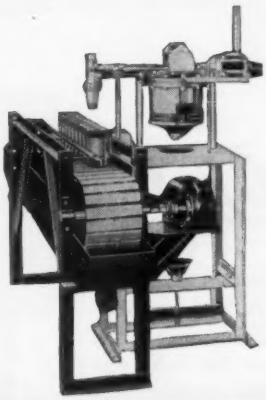
ELECTROMAGNETIC METERS



HANDLES CONDUCTIVE LIQUIDS WITH SOLIDS ENTRAINED

The Bowser "Xactronic" provides straight-line metering for conductive liquids, slurries, acids, etc., except oils. High-pressure or suspended solids are no obstacle. Exposed parts are Teflon and stainless steel.

PACKAGING UNITS



Available in many capacities. Electric or manual control. May be set for any quantity. Temperature and specific gravity adjustment dials provide greatest possible accuracy. Widely used for can and barrel filling. With or less conveyor.

CHECK ITEMS OF INTEREST BELOW AND MAIL COUPON FOR LITERATURE

XACTO METERS FOR INDUSTRIAL LIQUIDS ☐

BLENDING SYSTEMS FOR PRODUCTION ☐

PACKAGING UNITS FOR LIQUID PRODUCT ☐

INDUSTRIAL LIQUID FILTERS ☐

ELECTROMAGNETIC METERS ☐

DATE_____

NAME_____ TITLE_____

COMPANY_____

ADDRESS_____

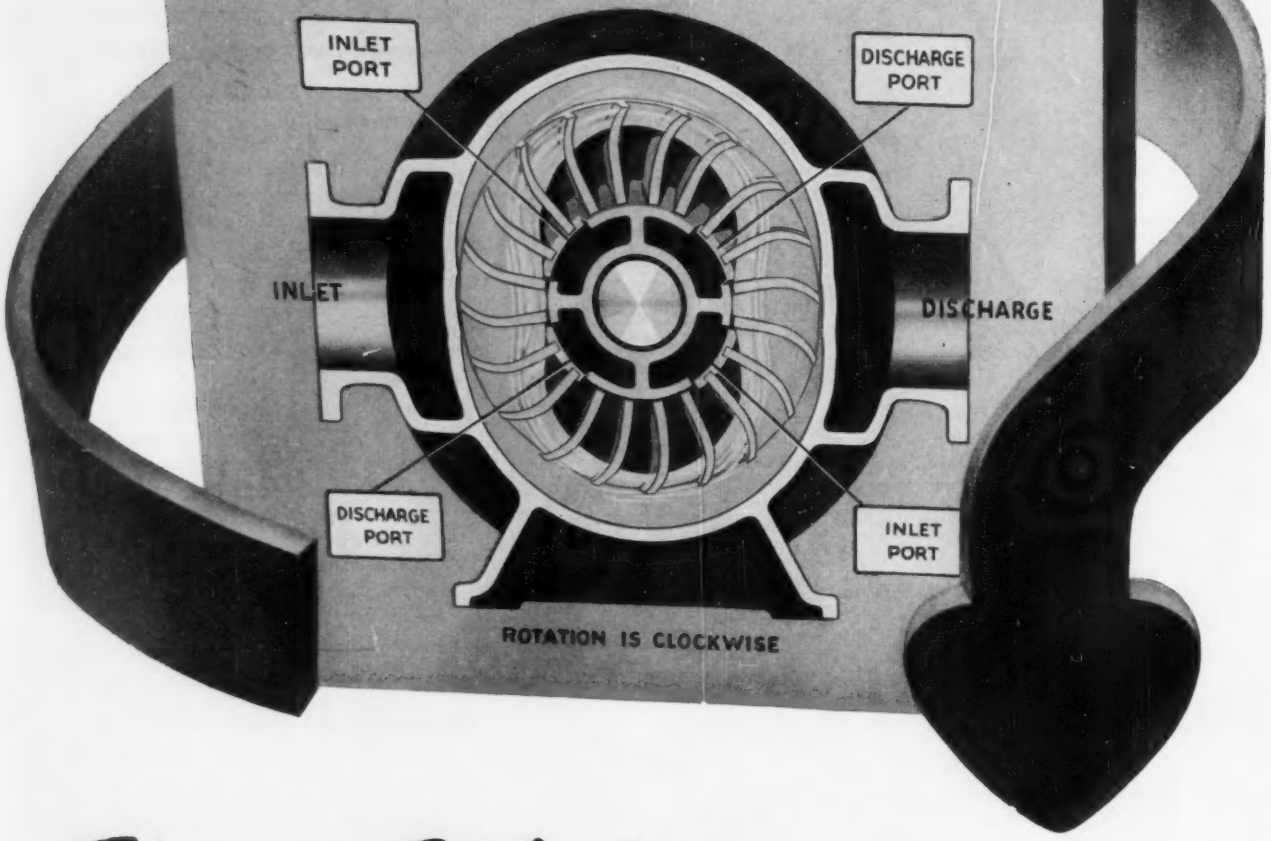
CITY_____ STATE_____

PRINCIPAL LIQUIDS_____

BOWSER, INC., FORT WAYNE, IND.
1367 E. CREIGHTON AVE.

For more information circle **37** on inquiry card.

Nash Instrument Air Compressors deliver only clean air, free from oil or dust, and without filters



Here is Why!

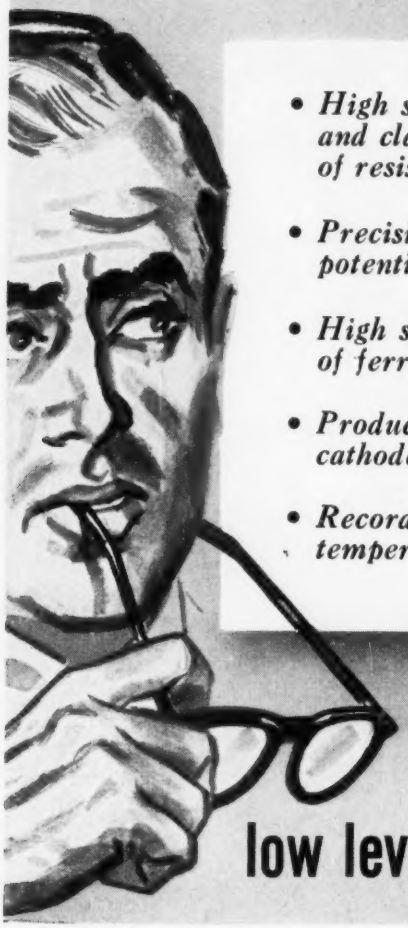
You can dispense with oil filters and dust filters when you install ®Nash® Clean Air Compressors. You can save the cost of maintaining these devices. You can greatly reduce instrument maintenance costs. For the Nash employs no internal lubrication, therefore no troublesome oil is in the delivered air. Moreover, air from a Nash is thoroughly washed and cooled as it passes thru the pump. Dust in the plant atmosphere, even fly ash, is immediately removed.

®Nash® Clean Air Compressors are simple, with only one moving element. No valves, gears, pistons, sliding vanes, or other enemies of long life and constant performance complicate a Nash. No aftercoolers are needed. You will find it profitable to investigate these pumps, now.

No oil filters.
No dust filters.
No internal lubrication to contaminate air handled.
No internal wearing parts.
No valves, pistons, or vanes.
Non-pulsating pressure.
Original performance constant over a long pump life.
Low maintenance cost.

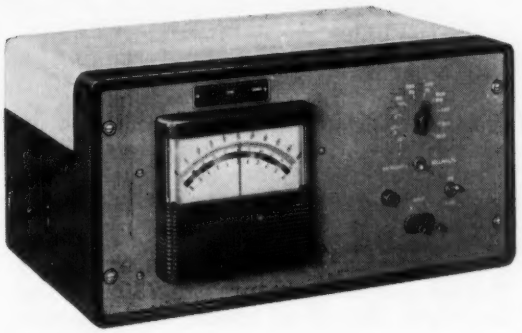
NASH ENGINEERING COMPANY
370 WILSON, SO. NORWALK, CONN.

These or similar problems puzzling you?



- *High speed inspection and classification of resistive elements*
- *Precision control of minute potentials and currents*
- *High speed inspection of ferromagnetic materials*
- *Production testing of cathode ray tube brightness*
- *Recording extremely low temperature differentials.*
- *Continuously recording rate of temperature change in jet engine test stands*
- *R.M.S. regulation of a-c oscillators and generators*
- *Multiplication of two a-c or d-c signals to provide a precision product*
- *Precision low power factor measurements for production inspection of transformers and motors*

The INDUCTRONIC® SYSTEM of low level MEASUREMENT and CONTROL



Model 1475 Multi-Range Inductronic D-C Amplifier provides amplification of a complete span of direct current and voltage ranges of either polarity with no sacrifice in fundamental accuracy or speed. Has seven current ranges, from 10 to 1,000 microamperes — and ten voltage ranges, from 1 to 1,000 millivolts. All ranges immediately available by the turning of a switch; and an additional seventeen ranges become available by a knob adjustment which changes the instrument from zero left to zero center. Accuracy 1%. Accessories such as recorders and additional indicators can be inserted in the output to a total of 5,000 ohms without affecting accuracy or calibration.

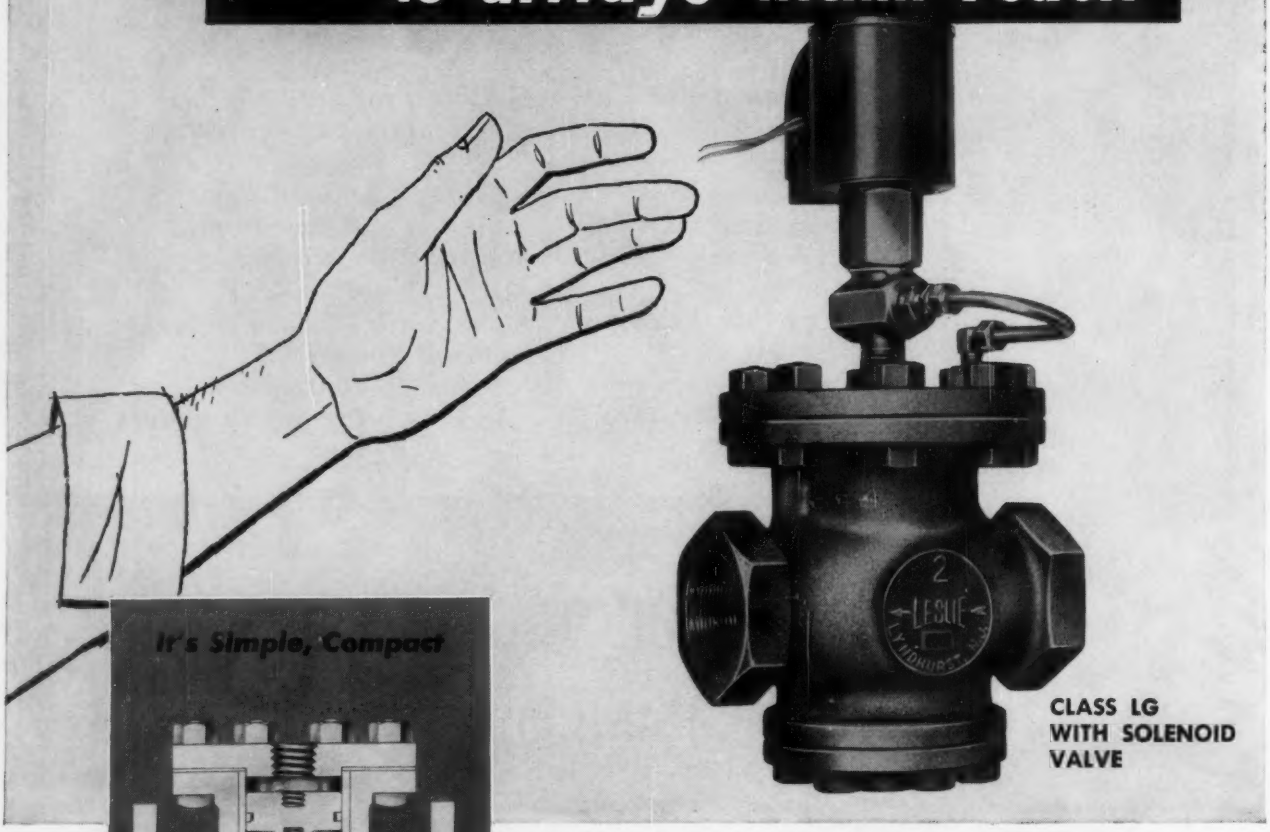
Practical solutions to the above, and many other problems of low-level measurement and control have been supplied by the WESTON Inductronic System . . . an entirely *different* method of d-c amplification. Utilizing the deflection of a permanent magnet moving coil system, it converts extremely low-level d-c to a proportionate a-c signal and amplifies it to a *usable degree* . . . then reconverts to a d-c level. The system operates at a frequency of 200 KC, and provides a high order of sensitivity, accuracy and speed. And because of circuit simplicity, the system is stable and virtually maintenance free. To learn how you can apply the Inductronic System in research or production, call your nearest Weston representative, or write direct for bulletin B-36-B.

WESTON *Instruments*

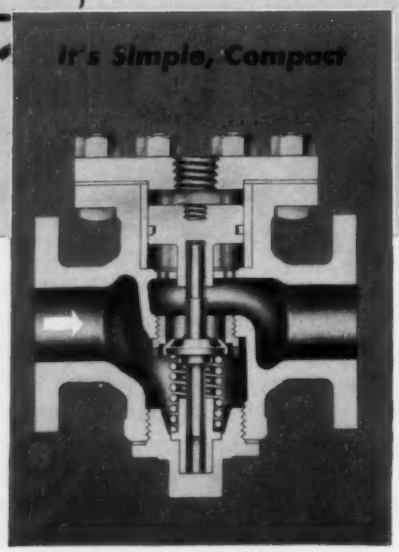
WESTON ELECTRICAL INSTRUMENT CORPORATION, 614 Frelinghuysen Avenue, Newark 5, New Jersey

For more informatio ncircle **38** on inquiry card.

This operating valve is *always* within *reach*



CLASS LG WITH SOLENOID VALVE



Simplicity and compactness keep cost *down*, reliability *up* in this Leslie Class LP operating valve.

Make a demand — the valve obeys. It's like having a third hand and a long arm as the control for this shut-off valve is *always* within *reach*.

You can get Leslie shut-off valves equipped with an electric solenoid valve (Class LG) or you can operate them remotely with an air or hydraulic relay valve. Valve opens and closes on demand of a manual or automatic signalling device (pressure switch, thermostat, etc.)

Designed for off-on service, there are units with body ratings to 1,000 psi and temperatures to 750°F. The valves give fast, tight shutoff of steam, air and non-corrosive fluids.

Ask your Leslie engineer to help you select the operating valve that's engineered to meet your service requirements. You'll find him listed under "Valves" or "Regulators" in your classified telephone directory.

Bulletin 5309 describes operating valves.
Send for it today.

TRADE LESLIE MARK

REGULATORS AND CONTROLLERS

LESLIE CO., 299 GRANT AVENUE, LYNDHURST, NEW JERSEY

131

CONTROLLED QUALITY MEANS QUALITY CONTROLS

For more information circle 39 on inquiry card.

NEW ATOMIC CANNON

Added Evidence that—

Everyone Can Count on VEEDER-ROOT

This mobile 280 mm. atomic cannon has *two* recoil motions. The primary recoil absorbs the cannon's "kick". The secondary recoil (something new in artillery) absorbs the forces created by the primary recoil. And each recoil motion is recorded by this special Veeder-Root Counter designed with a plunger-action shaft . . . which keeps the score on the cannon's use and indicates approaching need for maintenance.

This again points up the fact that "Anything Worth Making — or Worth Doing — *Is Worth Counting.*" And Veeder-Root has the experience and resources *you* can count on, to give you any counter you need . . . for any mechanical or electrical application . . . in any field from Atomics to Automation. Write:

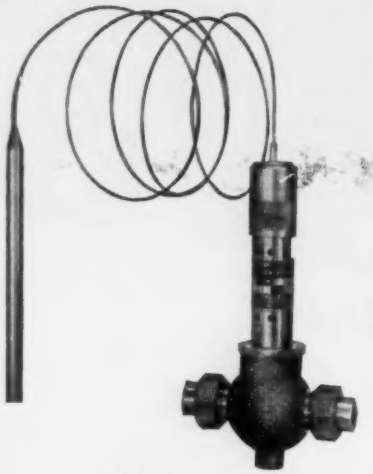
VEEDER-ROOT INCORPORATED
HARTFORD 2, CONNECTICUT

Chicago 6, Ill. • New York 19, N. Y. • Greenville, S. C.
Montreal 2, Canada • Dundee, Scotland
Offices and Agents in Principal Cities

"The Name that Counts"

For more information circle **40** on inquiry card.

CUT STEAM WASTE 2 WAYS with Klipfel THERMOSTATIC VALVES



Klipfel No. 1449
Temperature Control Valve

Control that's accurate plus positive tight closing make Klipfel Thermostatic Valves real steam savers in operation.

Vapor pressure operated, these tank thermostats give control that's dependably sure . . . always.

Two types of single seated inner valves—both successfully proved on Klipfel's pressure reducing valves—are available for permanent tight closing.

Stainless steel ball inner valve and seat bushing with integral guides stops steam leakage, prevents wasteful, damaging overheating.

For high pressure applications and in larger sizes, Klipfel's pilot balanced, cup disc type inner valve gives the same advantage of dead end closing.

For complete details, write Dept. C-11 for Bulletin 354.

Float Valves, Reducing Valves, Tank Thermostats, Back Pressure Valves.

Klipfel
VALVES, INC.
Div. of Hamilton-Thomas Corp.
Hamilton, Ohio
Export Dept., 1010 Schaff Bldg.
Philadelphia, Pa.

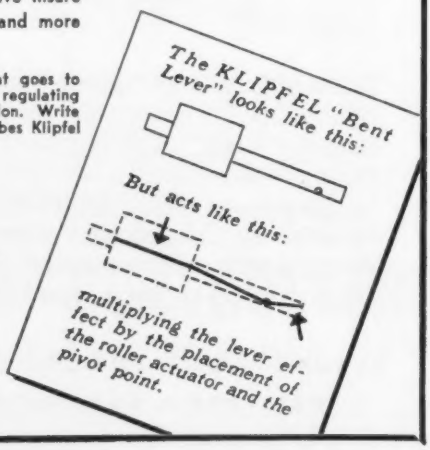
Obeying the law of supply and demand...

Klipfel "Bent Lever" REDUCING VALVE

It is the function of all reducing valves to increase or decrease the supply so as to maintain a constant reduced pressure when an increase or decrease in demand tends to lower or raise it.

The pitot tube control and the "Bent Lever" action found in the KLIPFEL No. 310 Reducing Valve insure more prompt response to demand changes and more uniform reduced pressures.

These features are a sample of the engineering that goes to make KLIPFEL Reducing Valves and other automatic regulating valves more dependable—more accurate in regulation. Write Dept. C-11 for your copy of Bulletin 154, which describes Klipfel Reducing Valves.


The KLIPFEL "Bent Lever" looks like this:
But acts like this:
multiplying the lever effect by the placement of the roller actuator and the pivot point.

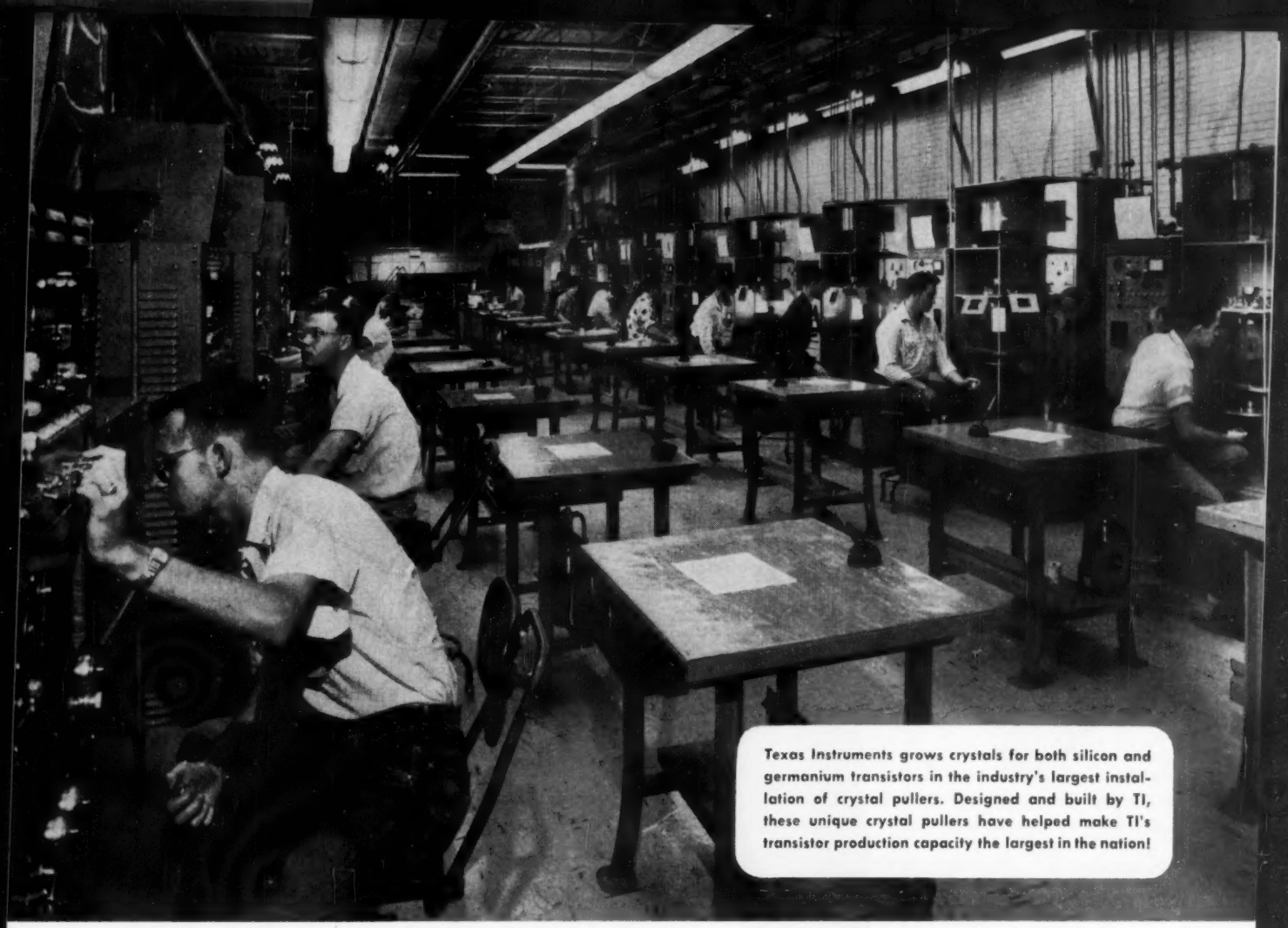
Klipfel

FLOAT VALVES
REDUCING VALVES
TANK THERMOSTATS
BACK PRESSURE VALVES

Sold through wholesalers everywhere

VALVES, INC.
DIVISION of HAMILTON-THOMAS Corp.
HAMILTON, OHIO
Export Dept. 1010 Schaff Bldg., Philadelphia, Pa.

For more information circle 41 on inquiry card.



Texas Instruments grows crystals for both silicon and germanium transistors in the industry's largest installation of crystal pullers. Designed and built by TI, these unique crystal pullers have helped make TI's transistor production capacity the largest in the nation!

ORDER FROM THE WIDEST LINE OF SEMICONDUCTOR DEVICES

GERMANIUM RADIO TRANSISTORS

SILICON TRANSISTORS

SILICON POWER TRANSISTORS

SILICON JUNCTION DIODES

N-P-N AND P-N-P GENERAL PURPOSE TRANSISTORS

PHOTOTRANSISTORS

GROWN JUNCTION TETRODES

HIGH SPEED SWITCHING TRANSISTORS

WRITE FOR LITERATURE

TI mass production means transistors today . . . not "available soon"

You get immediate delivery . . . in the quantity you need . . . when you order transistors from Texas Instruments. Mass production methods mean *no waiting* for silicon or germanium transistors . . . and at low prices! Only from TI can you get high temperature silicon transistors. Only from TI can you get *product-proved* germanium radio transistors. With the industry's largest transistor production capacity, TI can meet your delivery requirements – whether you need radio-type transistors by the hundreds or hundreds of thousands!

Texas Instruments low cost germanium radio transistors are used in the *first* transistorized consumer product – a high performance pocket radio on sale across the nation. High temperature silicon transistors (stable to 150° C), produced only by TI, are already being used in important military and commercial applications.

Each TI semiconductor product is glass-to-metal hermetically sealed . . . thoroughly aged and tested . . . to assure successful performance and long range reliability. The nation's leading manufacturer of transistors, Texas Instruments is your most experienced source for semiconductor products.

TWENTY-FIFTH YEAR OF PLANNED GROWTH

TEXAS INSTRUMENTS
INCORPORATED
6000 LEMMON AVENUE DALLAS 9, TEXAS

For more information circle 42 on inquiry card.

CRESCENT ARMORED MULTITUBE

for use with
INSTRUMENTS
and
PROCESS CONTROL EQUIPMENT

Tubes furnished in
Copper
Aluminum
Steel
Polyethelene

—

Special Construction for Underground Runs

The tubes are **spirally cabled** together which allows flexibility with absolutely NO DISTORTION OF THE TUBES. You can realize substantial savings in moderate to long runs up to 1000 feet of 2 to 19 tubes, ¼" O.D. Corrosion resistant constructions are also available.

CRESCENT ARMORED MULTITUBE is an armored group of long length tubes twisted together to permit bending without any distortion of the tubes, which are thoroughly protected from injury during and after installation by a flexible, inter-locked, galvanized steel armor.

One tube in each layer has a bright blue color, which permits a ready identification of each tube at both ends without the necessity for tracing through each tube. The relative position of each tube in each layer, with respect to the color-coated tube in that layer, remains the same throughout any length of ARMORED MULTITUBE. Licensed under U.S. Patent 2,578,280.

SEND FOR BULLETIN GIVING COMPLETE INFORMATION AND ENGINEERING DATA

CRESCENT INSULATED WIRE & CABLE CO.

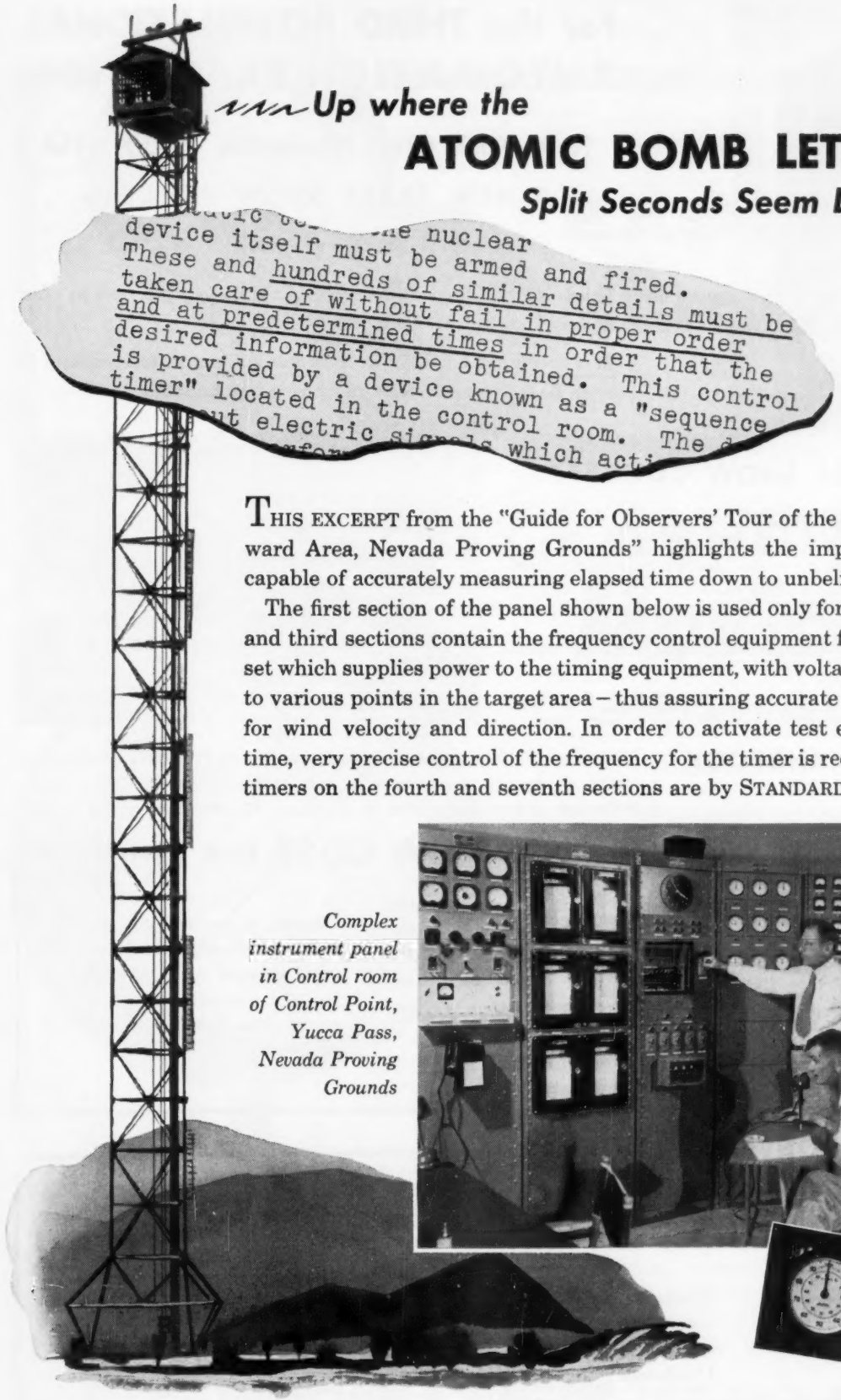
Olden & Taylor Aves. *Trenton, New Jersey*

For more information circle **43** on inquiry card.

Up where the

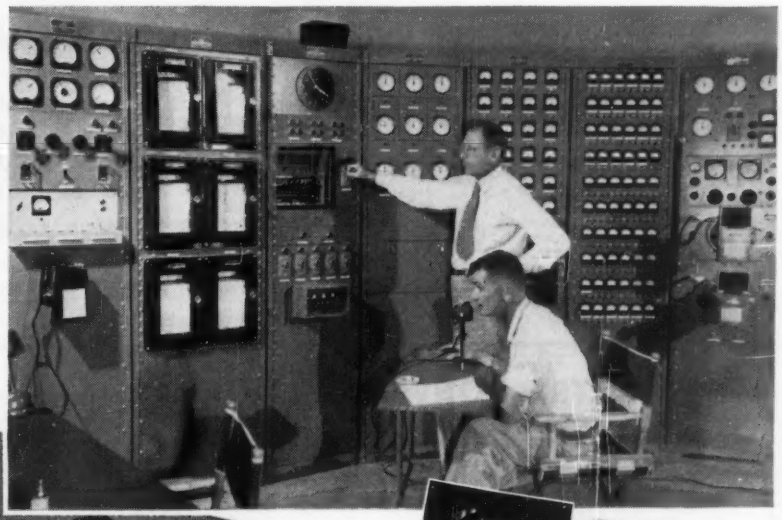
ATOMIC BOMB LETS GO

Split Seconds Seem Like Eternity

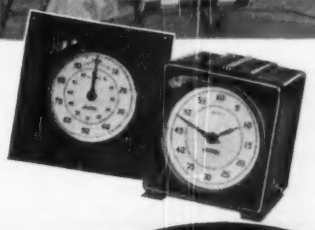

device itself must be armed and fired.
These and hundreds of similar details must be
taken care of without fail in proper order
and at predetermined times in order that the
desired information be obtained. This control
is provided by a device known as a "sequence
timer" located in the control room. The

THIS EXCERPT from the "Guide for Observers' Tour of the Control Point and Forward Area, Nevada Proving Grounds" highlights the importance of equipment capable of accurately measuring elapsed time down to unbelievably short intervals.

The first section of the panel shown below is used only for air bursts. The second and third sections contain the frequency control equipment for the motor-generator set which supplies power to the timing equipment, with voltage recorders connected to various points in the target area – thus assuring accurate timing – and recorders for wind velocity and direction. In order to activate test equipment at the exact time, very precise control of the frequency for the timer is required... The precision timers on the fourth and seventh sections are by STANDARD.



Complex instrument panel in Control room of Control Point, Yucca Pass, Nevada Proving Grounds



The STANDARD ELECTRIC TIME COMPANY

STANDARD
Since 1884

93 LOGAN STREET • SPRINGFIELD 2, MASSACHUSETTS

PRECISION TIMERS • CHRONO-TACHOMETERS • LABORATORY PANELS • PIPELINE NETWORK ANALYZERS

For more information circle **44** on inquiry card.

For the THIRD INTERNATIONAL AUTOMATION EXPOSITION

New York City, November 26-30, 1956

A NEW TRADE SHOW BUILDING

at 500 Eighth Avenue, New York City

Third International Automation Exposition will occupy five floors—2nd, 3rd, 4th, 5th, and 6th.

Rest rooms on each floor . . . water coolers in four corners of each floor . . . restaurant and bar in the building.

A NEW TRADE SHOW CONCEPT

Each "booth" an individual **air-conditioned** room . . . can be locked at close of show each day . . . . each exhibit **visible** from hall.

Refreshments can be served **in** the rooms; also will be available from serving carts **during open hours of the Show.**

Special shelving for each room optional at NO CHARGE . . .

Exhibitor personnel may set up **own exhibit;** additional labor also available through the service desk . . .

Crate storage in basement **or in exhibitor's own display room.**

AUTOMATION HANDBOOK

FREE space (7x10" page for each booth) in the HANDBOOK enables all exhibitors to describe the products in their exhibit—thereby extending the effectiveness of their participation in the Show. All registrants receive a copy.

A NEW LOW COST FOR EXHIBITORS

All-inclusive price of $4.00 per square foot includes: Handling exhibit material from receiving platform of building to your booth; electric current (to 3,000 watts); general lighting (about 50 foot-candles); one spotlight; furniture (2 tables, 2 chairs, 1 smoking stand, 1 costumer); telephone; crate storage; name sign; asphalt tile floor; cleaning; and handling exhibit material from booth to shipping platform at end of show.

***Second floor is an open exhibit area laid out in usual booth style.**

Exhibitors in the Second International Automation Exposition have a priority in the choice of their exhibit space at the Third International Automation Exposition, New York City, November 26-30, 1956.

A NEW ULTRA-CONVENIENT LOCATION

500 Eighth Avenue, between 35th and 36th Streets, New York City.
One block from the Pennsylvania and Long Island Railroad Stations
Tunnel connection from Station, Statler Hotel, and 7th Avenue Subway

8th Ave. Subway Station at corner
1 block from 7th Ave. Subway Station
1 block from Crosstown buses on 34th St.
2 blocks from Statler Hotel
3 blocks from Governor Clinton Hotel
4 blocks from West Side Highway
4 blocks from Lincoln Tunnel
5 blocks from International Bus Station
8 blocks from Queens Midtown Tunnel
8 blocks from Domestic and West Side International Air Terminals
15 minutes from Grand Central Station
20 minutes from Washington Bridge

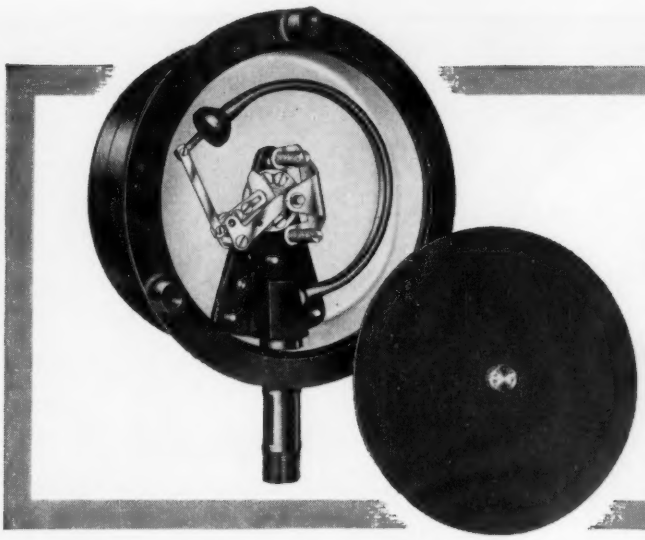
for more information, write, wire, or phone:

RICHARD RIMBACH ASSOCIATES

845 RIDGE AVENUE
PITTSBURGH 12, PA.

Phone:
FA-1-9831

For more information circle **45** on inquiry card.



EASY TO SERVICE...

a plus value of ASHCROFT

Maxisafe DURAGAUGES

Turn the knob on the back of the *Maxisafe* and the plate comes off, fully exposing the entire mechanism for fast and easy inspection, recalibration or adjustment. This time and money-saving feature is highly favored wherever Ashcroft *Maxisafe* Duragauges are in service.

This Duragauge was named *Maxisafe* because it has an integrally-cast wall to separate the dial from the movement and Bourdon Tube assembly — a solid wall of safety that protects the viewer if the tube ever ruptures. Covering the back of the case is a double spring mounted safety release plate — a Teflon-coated plate tightly fitted on a rubber gasket and held in place by a knurled knob. Less than 0.5 psi pressure created by a ruptured tube forces this cover open — vents the discharge safely to the rear.

The Maxisafe is available in 4½", 6" and 8½" dial sizes. You can have a choice of standard Ashcroft Duragauge pressure ranges, case designs (except Types 1179 and 1279), and mountings. Get the utmost in sustained accuracy, durability, protection and convenient servicing. Specify Ashcroft *Maxisafe* Duragauges.

YOUR INDUSTRIAL SUPPLY DISTRIBUTOR has complete facts about Ashcroft Gauges of all types. You can depend on his knowledge and experience to help you satisfy every requirement of the application. He maintains local stocks to serve you promptly and economically.

1850 ASHCROFT U.S.A.

ASHCROFT GAUGES

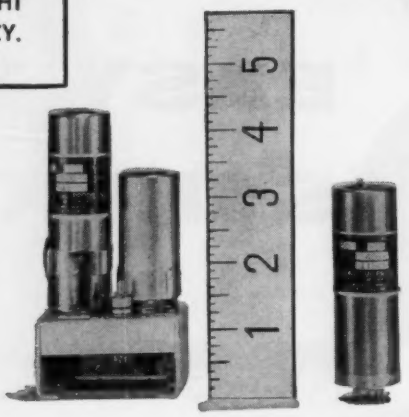
A product of **MANNING, MAXWELL & MOORE, INC.** STRATFORD, CONNECTICUT

MAKERS OF 'ASHCROFT' GAUGES, 'AMERICAN' AND 'AMERICAN-MICROSEN' INDUSTRIAL INSTRUMENTS, 'HANCOCK' VALVES, 'CONSOLIDATED' SAFETY AND RELIEF VALVES, AIRCRAFT PRODUCTS. BUILDERS OF "SHAW-BOX" AND 'LOAD LIFTER' CRANES, 'BUDGIT' AND 'LOAD LIFTER' HOISTS AND OTHER LIFTING SPECIALTIES.

MANNING MAXWELL & MOORE INC. M M & M TRADE MARK

For more information circle **46** on inquiry card.

TYPE 50C, LEFT
TYPE 50, RIGHT
240 TO 800 CY.



Another "New"

SUBMINIATURIZED

Introduced here are miniature versions of our popular Type 2003. They have equivalent accuracy but are much smaller, lighter and have fewer component parts. In the Type 50, all critical components are housed within the fork container.

Both the Types 50 and 50C offer superior shock resistance, up to 60 G. Hermetically sealed and shielded.

When requesting information, please state type number.

Precision

FREQUENCY STANDARDS ■ AND PRECISION FORKS

PICTURED AT LEFT, ABOVE

TYPE 50C SPECIFICATIONS

SIZE....2¼" x 2" x 4⅜" high. WEIGHT....8 ozs.
ACCURACY.....±.02% from —65° to 85°C
OUTPUT.....5V into 250,000 ohms
TYPE R50C.....Same as Type 50C with accuracy of ±.002% from 15° to 35°C

PICTURED AT RIGHT, ABOVE

TYPE 50 SPECIFICATIONS

SIZE....1" dia. x 3¾" high. WEIGHT....3.5 ozs.
ACCURACY.....±.02% from —65° to 85°C
OUTPUT.....5V into 250,000 ohms
TYPE R50.....Same as Type 50 with accuracy of ±.002% from 15° to 35°C

For 17 years this company has produced precision frequency standards for integration in highly accurate instruments and timing devices of our own and other manufacture. We make frequency standards within a range of 30 to 30,000 cycles, a field in which we offer maximum accuracy, simplicity and durability. Our products are now serving in many and varied applications—in industry, government (including the armed services, particularly in the field of aviation) and for laboratory uses.

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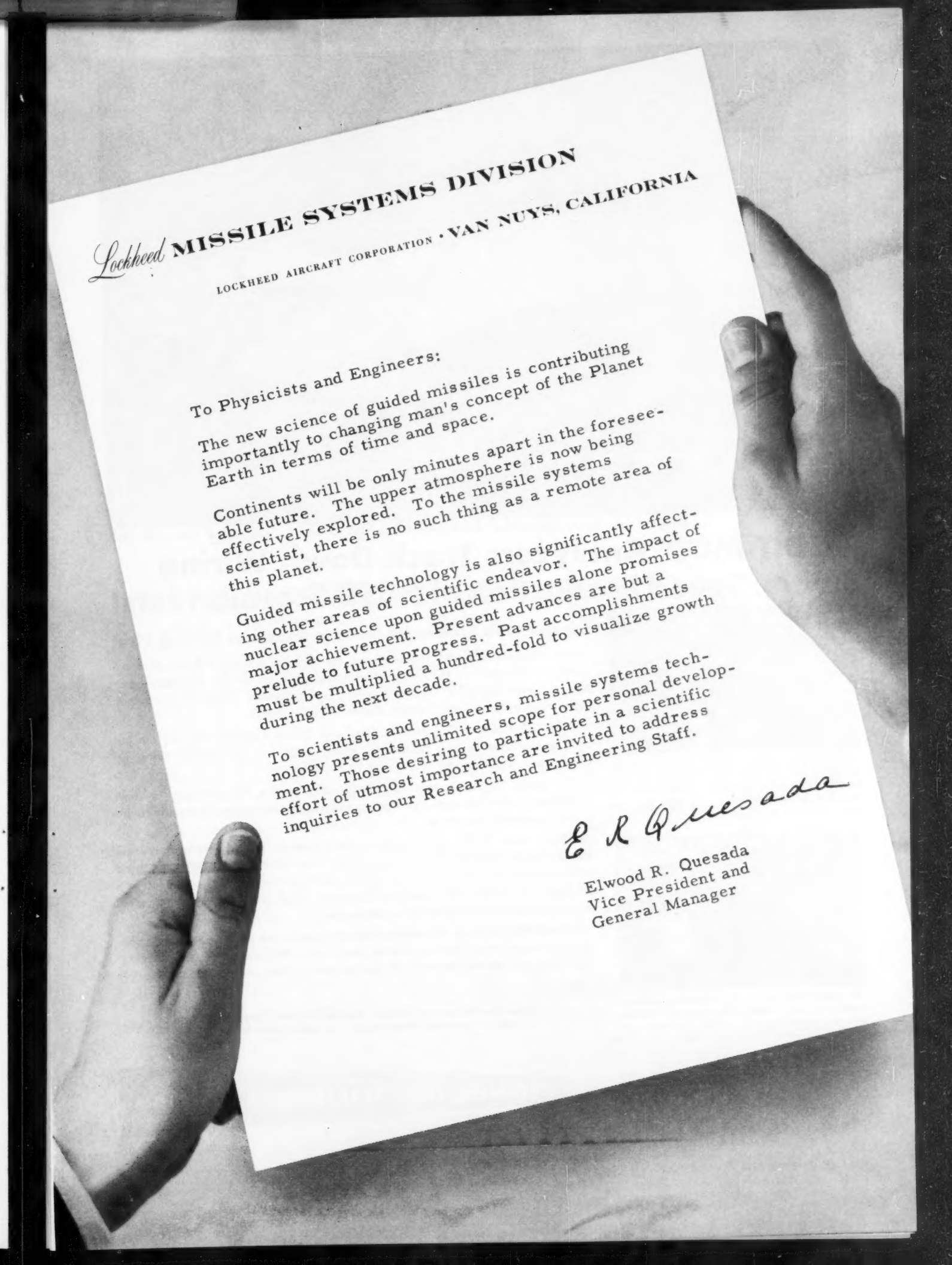

Lockheed MISSILE SYSTEMS DIVISION

LOCKHEED AIRCRAFT CORPORATION · VAN NUYS, CALIFORNIA

To Physicists and Engineers:

The new science of guided missiles is contributing importantly to changing man's concept of the Planet Earth in terms of time and space.

Continents will be only minutes apart in the foreseeable future. The upper atmosphere is now being effectively explored. To the missile systems scientist, there is no such thing as a remote area of this planet.

Guided missile technology is also significantly affecting other areas of scientific endeavor. The impact of nuclear science upon guided missiles alone promises major achievement. Present advances are but a prelude to future progress. Past accomplishments must be multiplied a hundred-fold to visualize growth during the next decade.

To scientists and engineers, missile systems technology presents unlimited scope for personal development. Those desiring to participate in a scientific effort of utmost importance are invited to address inquiries to our Research and Engineering Staff.

E R Quesada

Elwood R. Quesada
Vice President and
General Manager

Firing 2.75 inch rockets in coveys of 104, this Northrop Scorpion F-89D can down the largest bomber with a single blast.

DIT-MCO Analyzers Track Down Wiring Errors, Speed Production of F-89D Scorpion Jets!

DIT-MCO analyzer in use checking harnesses on wiring jig board at Northrop. The Model 200 reduces costly rework of wiring systems, after installation, by locating errors *early* when they are easy to correct.

The same tester in use on an entirely *different* cable assembly. Some manufacturers use one DIT-MCO Circuit Analyzer to check as many as 50 different harnesses in a single day!

Complex Cable Systems Are Tested In Seconds at Northrop Plant

Like all modern aircraft, this Northrop interceptor is actually a flying electrical system. It depends on thousands of complex electrical circuits for every operation . . . from canopy to electronic aiming and automatic triggering equipment. Small circuitry errors could cause disastrous malfunctions.

DIT-MCO Model 200 Automatic Electrical Circuit Analyzers are on the job daily at Northrop, helping to eliminate wiring errors . . . . both on the wiring jig boards and after harness installation *in the airplane*.

The model 200 is capable of checking 200 circuits, for continuity or short resistance, in less than a minute. Making these same tests manually would require 35,800 separate operations.

What's more, the analyzer *never* makes a mistake, it is so simple to operate that it almost eliminates human error, and it can detect minute flaws which no other machine or human can find. All this speed and accuracy is contained in a package so mobile that some manufacturers check as many as 50 different harnesses, with one machine, in a single day.

It's wasteful to tie up experienced quality control and production line personnel with monotonous, time-consuming hand tests. DIT-MCO does the job better and faster and allows personnel to devote more of their time to actual corrective measures.

If Your Product Involves Complex Electrical Circuitry, DIT-MCO Can Help You Make It Better and Faster, at Less Cost. Write Today for Full Details.

DIT ★ MCO

DIT-MCO, INC. ELECTRONICS DIVISION

507 West 9th St. Kansas City, Missouri

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Long-Lasting,
Constant-Voltage

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Mercury Batteries

Portable thermistor-type temperature indicator uses Mallory battery No. TR-132R.

For your portable instruments

TO POWER the portable instruments you are designing, it pays to incorporate the unusual performance of Mallory Mercury Batteries. They give you a power source that offers the tops in long life and dependability. In the temperature indicator pictured here, Mallory Mercury Batteries deliver more than 500 hours of continuous operation . . . in the radiation detector, more than 100 hours.

Their constant-voltage, constant-current discharge protects against changes in instrument accuracy. Mallory Mercury Batteries, moreover, can withstand long periods of storage and extremes of temperature and humidity without deterioration. And they are so small that they fit readily into miniaturized, light-weight equipment. Their constant-energy characteristic is ideally suited to use in transistor circuits.

A wide selection of capacities and voltage ratings is available. For complete data on Mallory Mercury Batteries, write today for our latest Technical Bulletin.

Portable radiation monitor can run two weeks continuously on its Mallory Mercury Batteries . . . or up to 2 years on intermittent service.

Parts distributors in all major cities stock Mallory standard components for your convenience.

Serving Industry with These Products:

Electromechanical—Resistors • Switches • Television Tuners • Vibrators
Electrochemical—Capacitors • Rectifiers • Mercury Batteries
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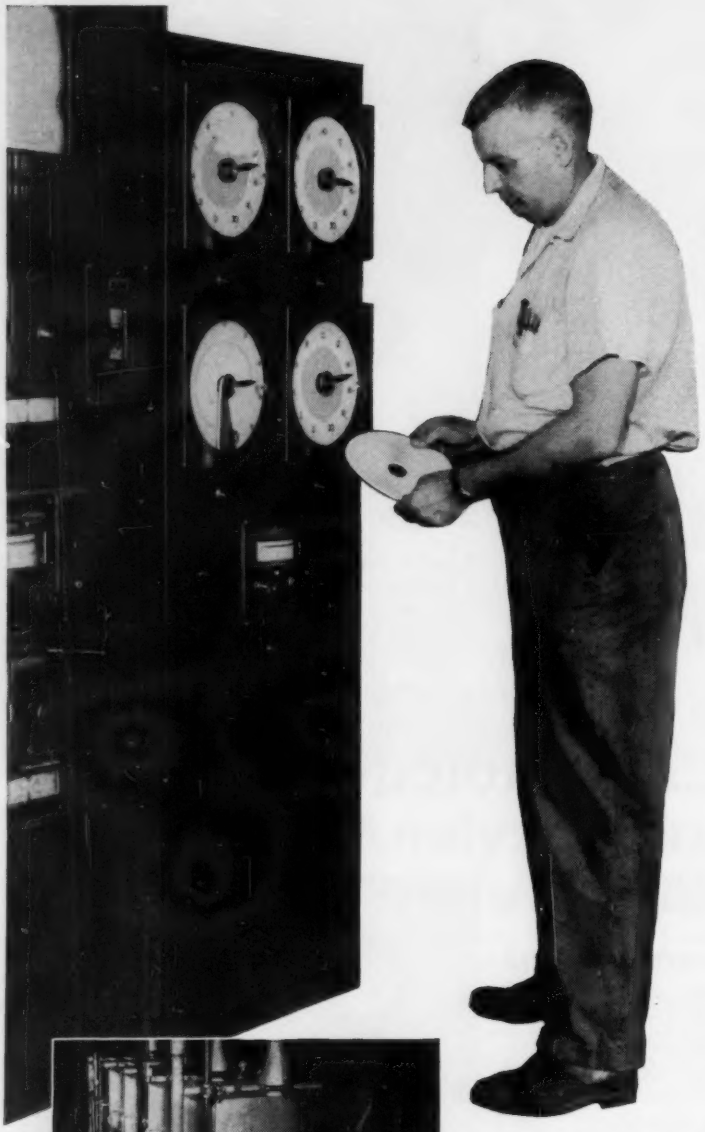
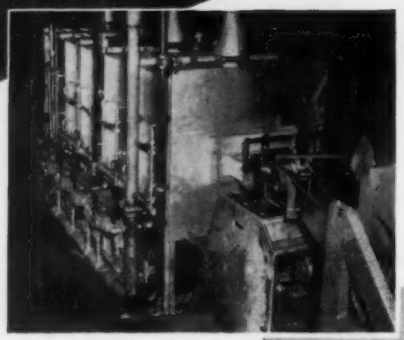
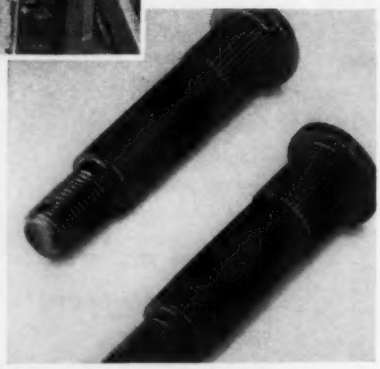


Foreman examines Speedomax H control record chart for furnace shown.



Four-zone American Gas Furnace Co. shaker-hearth furnace, Lamson & Sessions Co., Cleveland.



Special bolts immediately after heat-treatment. Lamson & Sessions headed and threaded products of all kinds are handled by the Speedomax-controlled furnace.

FASTENER MFR. NOW USES

Speedomax® H

TO CONTROL HARDENING FURNACE

Lamson & Sessions finds new instrument easy to read, easy to set, small and easy to install

• Heat-treatment in the production of bolts and other fastenings is an old story to Lamson & Sessions in their big plants around the country, but they have recently come up with what looks like a real improvement in control at their Cleveland factory. When they added another American Gas Furnace shaker-hearth unit, they decided to equip it with the new Speedomax H controllers, and they're well pleased with results. Here are features they like:

1. Easy to read at 20 feet; both for operator at furnace and for foreman as he walks down the aisle.

2. Space-saving size; panel for a 4-zone furnace is considerably narrower than older panels for a 3-zone unit . . . especially interesting when space in heat-treating department costs several dollars a foot per year.

3. Quick and easy setting of control point; saves time of busy instrument men.

4. Quick and easy to get; no Speedomax H shipment has lagged by as much as one day.

This compact, trustworthy companion to our older, much larger Speedomax G can't do the unusual things the G does, but it gives you a solid, fully accurate job of either on-off control or of two-or-three-function control for hundreds of processes.

Speedomax H is made as an Indicator only, as an Indicating Controller, and as either Round-chart or Strip-chart Indicating Recording Controller. You can get complete description and full application-engineering service from our nearest office or from 4955 Stenton Avenue, Philadelphia 44, Pa.

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Editorial...

INSTRUMENTS and AUTOMATION

CONGRESSIONAL HEARINGS ON AUTOMATION

FOR two weeks, from October 14-28, a parade of witnesses testified before the Subcommittee on Economic Stabilization of the Joint Congressional Committee on the Economic Report, Washington, D. C., on "automation." The motivating force behind the probe was labor, which has seen in the word automation a lever for additional economic benefits of a broad character.

Readers of this publication are well aware that our position on the economic impact of automation is not "anti-labor," that it includes recognition of the fact that increased productivity resulting from technological advances of any type must be accompanied by increasing purchasing power. BUT, it has also been our oft-repeated policy to oppose any intimation that automation, per se, can affect the economic stability of the country, or the purchasing power of the nation as a whole, or the health of the economy in general. We have tried, time after time, to show that these latter problems depend on a host of economic factors far, far from the field of automation —and that all discussions of the "economic implications" of automation which ignore the over-riding economic causal factors become only pro-machine or anti-machine demagogy of no value, no matter what the side taken.

THE hearings, chairmanned by Representative Wright Patman (Democrat of Texas), became another of the "yes-it-will no-it-won't" debates now familiar to any reader of any newspaper or magazine, technical or non-technical, in the USA.

Joseph Beirne, President, Communication Workers of America—CIO, repeated his statistics about the declining number of operating employees in the Bell System in 1954 (ignoring the fact that in 1955 the number of operating employees has increased to new and unprecedented numbers); and predicted that jobs in the telephone industry will decline by 200,000 by 1965 unless business increases "offset" the effects of automation.

D. G. Mitchell, President and Chairman of Sylvania Electric Products Inc., testified that automation must be stepped up even more rapidly in the future if a serious labor shortage is to be averted.

CIO President Walter Reuther called for a 30-hour work week and offered an 8-point program (to cushion the effects of automation), including earlier retirement age, improved social welfare services, aid to small business, retraining of displaced workers, and corporate price policies designed to help consumers to enjoy the benefits of rising automation.

John Diebold, author and consultant, reassuringly generalized that "Automation holds no threat to our economy . . . it promises to invigorate the economy."

Young Associate Professor Walter S. Buckingham of the Georgia School of Technology said "If properly controlled, automation, together with atomic energy, may provide the means for eliminating poverty for the first time in the history of the world . . . The long-run outlook for labor is good . . . short-run problems may be acute."

Director of the Census Bureau Robert W. Burgess testified that automation will contribute to an expanding economy with more jobs, less work, and better pay; that there may be serious short-run dislocations; and that the telephone industry has almost doubled its employment in 10 years.

Dr. Cleo Brunetti of General Mills, Inc., predicted that automation will create 15 million new jobs in the next ten years, and recommended a 6-point program for minimizing "short-term dislocations," including the defining of new jobs, informing workers of new job opportunities, expanding educational facilities to reorient the displaced.

Secretary of Labor Mitchell told the committee that preliminary studies "indicate that there is no reason to believe that this new phase of technology will result in overwhelming problems of readjustment." He presented data showing that the rate of productivity gain in the USA has not changed materially. Mr. Mitchell also emphasized the need for emphasis on engineering and scientific education.

THESE few bits of testimony are chosen here to show not only that all sides of the great debate were presented, but that all degrees of all sides were "established" by facts, figures, and incontrovertible data.

We hold a dim view of all the various interpretations. The economic problems underlying every viewpoint are much too important to be treated as mere byproducts of automation; and it is uncomfortable to have automation considered as an over-riding economic causal factor, to find automation being used as the bogeyman to frighten the nation into considering some economic and educational programs, and to have so many responsible authorities entering the debate. The reassurances offered at the hearing will not solve unemployment problems, if any develop in the future. Nor will this unemployment be caused by automation.

We waited in vain for somebody to point out that everybody could be right—that the economic stability of the nation depends on factors other than automation; that there might be either 20,000 fewer or 15 million more jobs in 10 years; but that automation would not be responsible for either. Perhaps such a statement would have been out of place; it would have shown that the hearings were being held on the wrong subject if the intent were an honest investigation of factors that make for economic stability or instability, for an expanding or declining economy, for prosperity or recession, for job shortage or surplus. The result of this investigation is

that more people will believe the myth that automation can create jobs and an expanding economy—or the opposite but equally mythical premise that automation can destroy jobs and cause unemployment. Both of these myths turn attention away from the true causes of the situation being investigated—which is the question of how best to maintain our expanding economy.

The only constructive portions of the hearings were the economic and educational points offered in the programs of Brunetti, Reuther, and others. These programs (as well as others) should be re-examined as to their advantages and feasibility for sustaining and expanding the economy in general—but not because of any implied threat or promise of automation.—MHA

The Simulation Councils, Electronic Computers, And You!

DO you know what the Simulation Councils are? For that matter, do you know what we mean by simulation? And do you know how *you* fit into the picture?

We can answer the first two questions with brief facts, and we should like to show you how these facts are destined to affect you and your way of life.

Simulation, as we use the word here, means the use of electronic models to simulate physical systems. The models are constructed to operate according to the same mathematical equations which describe the actual system. Because the mathematical description of dynamic systems usually takes the form of a set of simultaneous differential equations, the electronic differential analyzer, more popularly known as the analog computer, is the tool used most extensively for simulation.

THE Simulation Councils are informal discussion groups organized to stimulate the exchange of information and promote the cross-fertilization of ideas in the field of simulation at the working level. There are now four Simulation Councils—the original Western, the Midwestern, the Eastern, and Southeastern. Meetings are held every second month, usually at different locations to allow an inspection of some simulation facility in connection with the discussion. Because the Councils are made up of leaders in the field, both designers and users of simulation equipment, their work has had and is having a powerful influence on the techniques, equipment, and growth of this important means of synthesis, analysis, and control.

So much for the facts. Now for the effect of these facts on you.

Every dynamic system must have some kind of control if it is to do useful work. Sometimes this control is inherent in the system, and sometimes it is designed into it. But all too often the system is designed and then the controls superimposed. If you are an instrument man or control engineer you are acutely aware of this. But whether you are or not, your way of life, the quantity and quality of the goods which are available to you, and the price you pay for them, depend on the efficacy of control of the processes producing them.

CORRECTION

In the article "Continuous Annealing of Specialty Steel," by T. J. O'Keefe, INSTRUMENTS AND AUTOMATION, October, 1955, Crucible Steel Company's headquarters were mistakenly identified as being in Midland, Pa. Midland is the location of Crucible's main plant. Headquarters are in Pittsburgh, Pa., as is the Park works with the annealing line described in the article.

How can simulation be used to improve control? Let us mention three possible ways and let those of you who will extend them to your own problems or to military situations.

FIRST, let us assume that a process is being designed. Most important parameters are known, but because of multiplicity of heat-exchange rates, feedback loops, time lags, etc., the dynamic response of the over-all system, and therefore the best method of control, is in doubt. Such a system. Once set up, the system can be modified at will log computer to set up blocks having the same transfer functions as the known elements of the proposed process, and then connecting them with similar forward and feedback loops having time lags like those of the desired system. Once set up, the system can be modified at will by simply turning a dial or changing a wire until optimum dynamic characteristics are obtained. Furthermore, other elements of the computer can be made to operate like various kinds of controllers which can be connected into the simulated process experimentally to determine the most efficient method of control.

NOW let's consider how simulation might be used to improve control of a process which is already in operation. As any instrument man knows, management takes a pretty dim view of experimenting with a plant which is making money. But an analog computer can be used to synthesize the process and the simulated plant can be experimented with to any extent necessary to determine if and how control can be improved.

These things have been done. There remains one big step. This is not simulation per se, but the taking of simulation techniques and equipments into the plant for actual control of the process which has been synthesized and analyzed in the laboratory.

To this end, by improving communications, and thereby improving simulation techniques and equipment and stimulating progress, the Simulation Councils are important to you.

That is why *Instruments and Automation* is keeping you posted on the activities of the Simulation Council by publishing the *Simulation Council Newsletter*.—JHM.

P. S.—This is also why you will be introduced to the men of importance in the fields of both simulation and instrument engineering in the new feature, "Biographies of Significance," which begins this month on pages 1847-49.

Biographies of Significance

SIGNIFICANCE

"MEN IN charge of the controllers and computers will become the key men in automated operations . . . Computers could put the instrument department in charge of all plant operations, could make the instrument department the systems manager" (*I&A*, October, 1954, page 1683).

With these words, *Instruments and Automation* began a series of activities aimed at introducing computer techniques, especially simulation, into the process industries. One important activity was the First Computer Clinic, held in New York in November, 1954. Another important activity was the inclusion of the *Simulation Council Newsletter* in *Instruments and Automation;* this has brought the problems and activities of the men already in the simulation field to the attention of process men.

Your editors believe that the bridge between the fields of simulation and process instrumentation will be made stronger from still closer contact between its most prominent individuals. Hence we invite you to meet the men who, as Chairmen of the Steering Committees of the Simulation Councils, have been responsible for the Council activities. John McLeod, Head of the Functional Simulation Branch, Guidance Division, Naval Air Missile Test Center, Point Mugu, Calif., your editor of the *S. C. Newsletter,* and founder and first chairman of the Western Simulation Council (the first of the Councils), was introduced to you in the April, 1955 issue of *I&A*. We now invite you to meet Stanley Rogers, second chairman of the Western Council. This biographical sketch tells much of the story behind the history and growth of the Computer Facilities at Convair-Pomona and Convair-San Diego.

Stanley Rogers

STANLEY ROGERS was born in Chicago, Illinois on October 4, 1908. He attended Occidental College, graduating in 1932 with an AB in Physics and Mathematics. Stan took various courses at Occidental College, University of Southern California, California Institute of Technology, and Massachusetts Institute of Technology.

Stanley Rogers

From 1932 to 1942, Stan worked for the Francis Bacon Foundation, Inc., General Communications Products Company and its subsidiary, Sound Equipment Corporation of California, and American Television Laboratories in Hollywood. In June 1942 he became assistant to Dr. DeForest in his personal experimental laboratory.

He married Ellen Marie Hansen in December 1940. In June, 1943 Stan accepted a position in Convair's newly-created Radio and Electrical Laboratories and was sent to MIT for four months of special training in radar and electronic airborne navigational equipment. He later developed a method for analyzing electrical loads on airborne generators using punched-card accounting machines for calculations and tabulations, which was the first engineering use of these machines at Convair.

Stan later became Head of the Analytical Group in Convair's Radio and Electrical Laboratories.

In 1948 a project system was introduced into the Radio and Electrical Laboratories, with each project doing its own analytical work. Stan was then put in charge of the first Reeves Electronic Analog Computer to be received on the Pacific Coast. Like all computer facilities, this one grew and grew. Late in 1950 he was placed in charge of the design and procurement of an additional $485,000 in computing equipment which was destined to go to Convair-Pomona. Additional computer facilities for Convair-San Diego were shortly thereafter authorized, and the design of the two computing facilities was carried on jointly by engineering teams representing both Convair divisions, under Stan's direction as Supervising Engineer and Dov Abramis as Senior Engineer.

Stan was elected Chairman of the Steering Committee of the Western Simulation Council in December 1953 to succeed the founder and first Chairman, John McLeod.

During the past three years Stan has been supervisor of the Analog Computer Facility at Convair-San Diego—which continues to grow; some $300,000 in new computing equipment is on order. The first portion of decimal digital differential analyzer equipment went into operation in June of this year. More of this equipment is due. An analog-to-digital and digital-to-analog converter for linking Convair's analog and digital computers to work on a single problem is planned for late 1955.

Recently Stan was placed in charge of the design and procurement of a large data-reducing and telemetering check-out system in addition to his Analog Computer Facility responsibilities.

He is a senior member of the IRE, an editorial reviewer for Proceedings of the IRE, and a reviewer for Transactions of the Professional Group on Electronic Computers. Formerly a member of the IRE Committee on Analog Computers, he is at present a member of AIEE, the AIEE Committee on Computing Devices, and the Subcommittee on Analog-to-Digital Converters. Besides all this, Stan is a member of the Adult Education Association, Phi Beta Kappa, and Alpha Kappa Delta.

He likes hi-fi music and college activities, and is interested in the Press Club.

Stan has published "Effects of Thermal Characteristics of Aircraft Generators on Load Analysis" (*Transactions AIEE,* December 1946); and, of special interest to computer people, he collaborated with Dov Abramis to prepare and present "Design Features of Two Large-Scale Analog Computers on the West Coast" (Typhoon Symposium III Quarter 1953).

NEW

17 POUNDS OF PRECISION:

DU MONT TYPE 331
CATHODE-RAY OSCILLOGRAPH

- Developed in close cooperation with a leading manufacturer of computers
- DC to 4 mc vertical bandwidth (Transient response, 0.08 μsec)
- Precise measurement of time intervals (from 2.5 seconds to 0.08 μsec)
- Accurate voltage calibration over range from 0.4 to 400 volts full scale
- Flat-face, tight-tolerance Du Mont Type 3WP- Cathode-ray Tube provides excellent deflection linearity and freedom from field distortions
- Three-times undistorted sweep expansion of *any* calibrated sweep. Any expanded portion may be positioned on screen

ADDITIONAL FEATURES

Illuminated calibrated scale
High impedance test probe supplied
May be continuously operated horizontally or vertically
Beam-gate output at front panel for triggering external devices
Swing-away chassis construction assures accessibility of all components for convenient maintenance
Probe, instruction manual, and other accessories stored in front panel cover

***AND BEST OF ALL, THE PRICE IS ONLY* $585**

Never before has so much high-quality performance been compressed into so small a package. Here, in well under a cubic foot, (7⅞" x 9" x 17½") are *complete* facilities for high-precision observation and measurement of signals from d-c to 4 mc and beyond.

With its wide-band features and excellent pulse response (0.08 μsec) the Type 331 is particularly well suited for maintenance of computers and radar systems, or wherever portability—without sacrifice in performance—is required.

And in this day of cluttered work benches, the compact design of the Type 331 means that for general applications, you have laboratory performance in half to a quarter the surface area occupied by other instruments of comparable function.

For complete details, write to the address below for the technical bulletin.

IMPORTANT SPECIFICATIONS

Cathode-ray Tube: Type 3WP.

Deflection Factor: (full gain) a-c or d-c input, 0.2 p-p volts full scale (1.8").

Frequency Response: (any control setting) flat from d-c to down not more than 30% at 4 mc.

Calibrated Sweeps: 0.5 second to 0.5 μsec per major scale division (0.45"); expansion of 3X available on all ranges.

Amplitude Measurement: 0.4 to 400 volts full scale in 7 ranges.

Size: 7⅞" x 9" x 19½" overall including cover; weight without cover, 17½ lbs.; with cover 19¼ lbs.

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SIGNIFICANCE

The biography of Chalmer Jones reveals a meteoric rise coupled with several developments of basic importance to the field of process instrumentation. While Mr. Jones was with the Berkeley Division, Beckman, as product line manager with the computer group, sales of the EASE computer rose from $600 to over $100,000 per month within the short interval of two years, illustrating the growing importance of the analog computer.

In 1954 Mr. Jones motivated a unique development that may do much to break an impasse that has been the subject of much impassioned pleading by your editor. It has been our editorial contention for several years that the analog computer can change the basic character of operating instrumentation (the instrumentation of the instrument department *within* the plant), but that this development is retarded by lack of empirical transfer-type descriptions of operating units—which only the instrument man in the plant is in position to produce. The impasse: the instrument man in the plant does not know how to begin to experiment with the computer in the plant—and without his empirical results nobody can solve efficiency problems of operating units. Several initial steps have been taken to break this impasse, including the "computer-in-plant joint experiment" now being evaluated by John McLeod, Jr., work by Don Eckman and Irving Lefkowitz at Case Institute, and work by Gernand at Esso in Baton Rouge.

Chalmer Jones has been responsible for a development that may assist in breaking the impasse described. He has developed an analog computer of flexibility and accuracy, yet with a price of less than $1000. The computer is described on pages 1914-15 of this issue; we take pleasure in introducing the man responsible for this development with its implications for the process instrument man.

CHALMER E. JONES

Chalmer Jones studied mechanical engineering with emphasis on vibrations at Rutgers, graduating in 1950 with a Bachelor of Science degree; then to Stanford for a master's in Business Administration. At that time he joined Beckman Instruments to help develop a new computer which they were considering marketing. Within three weeks he was in the field, traveling thousands of miles, discussing computer problems and applications with various laboratories, military installations and universities. Shortly the product was moved from Pasadena to Berkeley, California, and two men (the chief engineer and Chalmer) were transferred to this division; the product underwent considerable change and re-design.

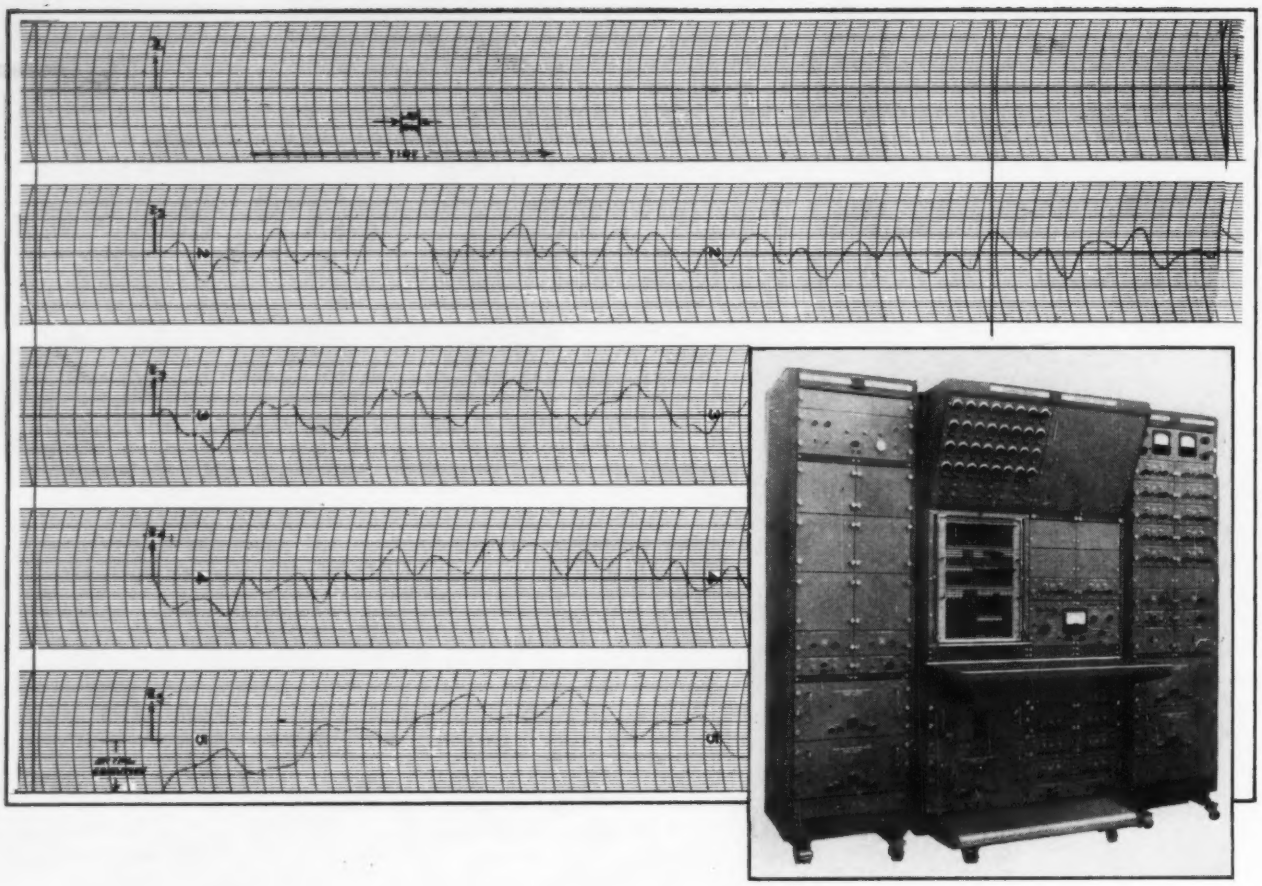
Chalmer E. Jones

Within a period of two years while Chalmer was with Berkeley, the EASE Computer shot from $600 per month to well over $100,000 per month, and was steadily climbing. The interesting fact which was learned there was that it was much easier to design a computer to what the customers felt they needed in the way of accuracy, convenience and flexibility than to engineer it and sell the customer on what was considered the "ideal" computer by its designers.

In 1954, Chalmer left Berkeley as product line manager with the computer group and joined Heath Company as Assistant to the President. Here he initiated a development of great importance. In his own words:

> "It has long been my conviction that computers, because of their great expense, have been slow in their application to industries where they may well be an economic and engineering necessity. We at Heath were in an enviable position in that we could design a computer with a high degree of flexibility, convenience and accuracy and put it into kit form, thus reducing the price. Whereas available general-purpose analog computers might sell for $8,000, this unit will be priced at under $700. This unit will find its applications as an engineering tool in industries, allowing solution of initial problems and acting as a proof to management of the necessity for larger facilities in the future.
>
> "Of course, the additional applications of such a unit in a university should not be overlooked. The unit is sold ala carte, with each unit carrying a separate price . . . As a matter of fact, a complete working computer can be had for under $250. We at Heath hope that this will offer a useable computer as well as a stepping stone to increase facilities in industries and universities. I personally feel that this will advance the industry one to two years in a relatively short time.
>
> "The preliminary response to the unit has been much greater than even the most optimistic at Heath. We, therefore, will continue to increase the line of instrumentation for computers.
>
> "The above represents a short period of time in which a lot of growth and development has been accomplished. Personally it has been most satisfying and stimulating."

← Circle 52 on inquiry card.



Application in structure dynamics and the unique building block expansion of EAI Computers . . .

An engineer was anxious to determine the vibration and stress of a beam, one end of which was to be solidly built into the support while the opposite end was to be unrestrained.

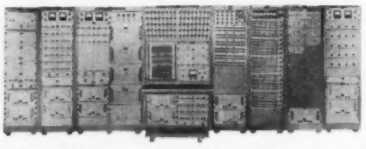
This engineer accomplished this on an EAI Analog Computer while the beam was still in blueprint stage. For on this computer, he was able to produce various modes of vibration by applying appropriate initial conditions at each of the nodes. The response of the nodes when an initial displacement of the tip station is suddenly released can be observed in the above illustration.

Naturally, in a problem such as this, it is important that the engineer be able to obtain the degree of accuracy needed to meet his specific requirements. This can be done on EAI Equipment, for EAI's unique building block system makes it possible to expand the computer to meet your specific needs. Thus by making use of more computing equipment, the engineer was able to divide the beam into more sections of smaller size and obtain a greater degree of accuracy.

Such features as this unique buiding block system, problem checks, automatic readouts, and powerful amplifiers have earned EAI Analog Computers an unsurpassed reputation for speed, accuracy, and efficiency.

Complete details on this equipment and on rental of time and equipment at The Computation Center in Princeton, New Jersey will be forwarded on request. Write Dept. IA-13, Electronic Associates, Inc., Long Branch, N. J.

EXPANDED 16-31R ANALOG COMPUTER



ELECTRONIC ASSOCIATES Incorporated

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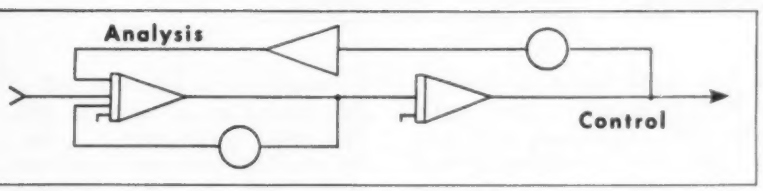
The SIMULATION COUNCIL Newsletter



John H. McLeod, Jr., EDITOR

Suzette McLeod, SECRETARY

1891 West Chapel Drive
Camarillo, Calif.

Western Simulation Council
Norman L. Irvine, Aerojet-General Corporation, Azusa, Calif.; Chairman, Steering Committee.

Midwestern Simulation Council
R. R. Weber, Cincinnati Milling Machine Co., Cincinnati, Ohio; Chairman, Steering Committee.

Eastern Simulation Council
Harold K. Skramstad, National Bureau of Standards, Washington, D.C.; Chairman, Steering Committee.

Southeastern Simulation Council
For information write W. K. McGregor, ARO, Inc., Tullahoma, Tennessee

OPINION RAMPANT
On A Field Of Facts

DO YOU believe that we are being overtaken in the race for technical supremacy? Do you believe that this endangers our national sovereignty, our independence, our way of life? I do, and I am not given to pessimism. In fact, I am not pessimistic now, because I believe there are several things we can do about it. But it will take some doing!

Your Ed. does not have any facts that are new and different. You all know them. But sometimes it helps to take a few recognized facts and lay them out orderly-like so we can see the whole picture—and where we fit into it.

In the light (or darkness) of the world situation there are a few prime facts which, taken together, reveal an intolerable situation:

(1) We must maintain military supremacy.

(2) Military supremacy depends upon technological supremacy.

(3) Technological supremacy depends upon technically trained people.

(4) The USSR is training a greater number of technical people than we are.

It doesn't take computer logic to see the penwriting on the chart!

Is there something wrong with my facts? Let's hope there is, and in that hope examine them more closely.

Must we maintain military supremacy? I think that for the foreseeable future you will agree that it is imperative. While praying that we never have to use it, we must maintain it, or our diplomats (some may say I use the term loosely) will be completely helpless.

The fact that modern military might depends on technological supremacy is incontestable.

There is likewise little room to question facts three and four individually, BUT, taken together they not only justify our hope but clearly indicate what must be done! Truly, technological supremacy does depend on technically trained people, but not necessarily on the *number* of technically trained people. If, while doing everything in our power to increase the number, we can also increase the quality of the work and the quantity of the output, we can prevail over a sheer numerical advantage.

Again, I have nothing new and different to offer, but suggest that we consider the total effect of pressing several simultaneous attacks on the problem.

FIRST, let's consider how more technically trained people might be made available. The obvious answer is to train more. This must be done, but first we will have to make technical jobs and the required scientific studies more attractive. Every company which is now crying for engineers and which expects to be in business ten years from now should arrange a traveling technical exhibit to be shown in high schools, even in grammar schools, for the express purpose of encouraging students to enter technical fields. And representatives of these companies—as well as all who are interested in the future of our country and a higher standard of living—should take every opportunity to address service clubs and other non-technical groups to extol the advantages of a scientific career. We are sold on it, or we wouldn't be in it. (Or is it the high pay?) So let's tell the school kids and all those people who might have school kids.

But education is for the future. A less obvious but more immediate way to increase the number of technically trained personnel is to modify some of our employment practices. Prejudice (or inertia) keeps many technically trained women in menial work, or discourages them so that they turn to "safety pins and bassinets." No secondary sex characteristic involving aptitude for technical work has ever been substantiated. And making part-time jobs available would help. Many technically trained women with homes and children to take care of would welcome an opportunity to escape to the peace and quiet of an office for a part of each day. Part-time jobs would probably be attractive to older men too—those

who have been forced to retire or who have been told by their doctor to slow down. These men, used to an active life, need something to keep them interested. And their experience would make them really valuable.

WE should do something about the technically trained people in jobs which fail to make full use of their technical training. Engineers should engineer, and scientists and others should do the work for which they were trained. Managements which permit an organizational structure that burdens technical personnel with more and more administrative work as they ascend the ladder are fostering a system which can often severely limit the organization's technical capabilities. All too often management finds that a promotion intended to reward a deserving engineer has not only deprived them of his technical know-how but has got them a poor administrator besides. There are exceptions, I know; there is nothing inherently incompatible about technical and administrative ability. However, because the training required to make a good engineer is different from that required to make a good administrator, the man who does equally well in both capacities is too rare to justify an organizational structure predicated on his kind being in plentiful supply. I also realize that there are jobs which require the administrator to be technically trained. In these cases the organization should be such as to make the most effective use of the man's technical capabilities by providing adequate staff assistance. With technical people in short supply it is ridiculous to have them typing their own memos, answering the phone for others, doing their own expediting or other legwork, or in short doing anything which can be done by others and which is less important than their technical work.

Having considered possible means of (1) increasing the number of technically trained people available, and (2) directing more of the effort of those now employed into technical channels, let's turn our attention to means of increasing the quality and quantity—the effectivness of the work of all technically trained personnel. Though your Ed. believes that *all* possible pressure should be brought to bear on the problem, it is this latter attack which, I believe, will yield the greatest returns for our efforts. Here we have precedent to guide us; we can learn from the experience of management in their spectacularly successful effort to increase the effectiveness of the industrial worker. They gave him better and more powerful tools and taught him how to use them. In return the worker gave to all of us the highest standard of living the world has ever known!

FORTUNATELY, we are now in a position to give the technical worker better and more powerful tools—and the results should be even more important than the Industrial Revolution. The better and more powerful tools are, of course, the equipment and techniques for machine computation. And the reason for the greater importance is that they will not only help us to accomplish our primary objective—that of increasing the technical man's capabilities—but they can also be applied to machine tools to increase their capabilities. Thus they will compound their effect. This will take some doing, for it will entail a prodigious educational effort. Computer manufacturers are ready and eager to supply the computers. But management must be taught their value, scientists must be educated in their use, and technicians must be trained to install, maintain, and repair them. This won't be easy. The equipment is expensive, and those with enough experience to teach its use are few.

To give some insight into the problem, let me quote from a letter received from J. N. Macduff, Professor of Mechanical Engineering at Rensselaer Polytechnic Institute:

> "I have been reading with considerable enjoyment, interest and hope your *Simulation Council Newsletters* in *Instruments and Automation* magazine. It is a pleasure to be able to absorb technical information without having to wade through several tons of stuff-shirted English.
>
> "My interest and hope in your project arises from my plight in attempting to teach Mechanical Engineering students in the general area of Serendipity*, Mechanical Controls, Design, Mechanical Vibrations, and Use Your Head. Our system is closely coupled with the usual academic situation of practically no budget, infinitely small laboratory space, and high impedance of all hands.
>
> "My hope is that the great Chiefs of the Simulation Council will occasionally remember that in most well regulated tribes there are often more Indians than Chiefs. Could the steering committee once in a while devote a session to the problem of educating the future engineers of the nation in the uses and possibilities of simulation.
>
> "It will take considerable effort and skill at impedance matching for such a discussion to be of value. For student use, and I mean student use with their own little hands, we have a home-made baby analog simulator consisting of 10 Philbrick operational amplifiers. Our precision resistors and capacitors are the normal 20% variety we steal from our electrical friends. This is horrible enough to make the normal Big Chief take to firewater. We, however, do achieve our purpose of giving the student a basic insight into the possibilities and uses of an analog simulator, and also acquaint him with the strange and wonderful language used.
>
> "In this area, the engineering educator needs help in the way of simple and cheap suggestions. Some items that might be of considerable value are:
>
> 1. Listing of references that are primarily for the amateur.
>
> 2. Suggestions of ways of building cheap function generators, plotting tables, nonlinear circuit elements and similar devices. Note that most of the devices listed in such works as Korn and Korn are beyond the means and time of the average educator.
>
> 3. Suggestions of circuits for simple digital devices. A digital computer for solving a sixth to tenth order determinant with the students pushing the buttons for input and reading the output on light bulbs would be of the right order of magnitude. We are trying to encourage serendipity and not make complete experts.
>
> 4. Passing of the word that schools are charitable institutions which would welcome the direct gift of hardware. I would love to have someone give me a Goodyear computer with the string attached that it was for student use only, but I would also welcome a box full of old resistors, potentiometers or similar useful parts.
>
> 5. Visits from the Big Chiefs.
>
> 6. Item h from Table 1, page 1308, *Instruments & Automation*, Vol. 28, No. 8.*
>
> "I trust that this will give you some insight into our problems and stir up some interest in our efforts to educate customers. I am sure that you must have many, and I hope, rabid ideas on the subject, so don't spare the horses. We will certainly appreciate any suggestions you can send this way."

*The knack of finding that which is not specifically searched for, particularly something pleasant or beneficial.—ED.

*This was "prayer"!—ED.

Now see what I mean "It'll take some doing"? Here is a man in a position to contribute to the salvation and improvement of our way of life. But his efforts are severely handicapped by lack of a few millibucks. If he were able to educate *one* engineer to use *one* computer to solve *one* problem which would eliminate the need for one of our more elaborate guided missile flight tests, he would save us taxpayers enough money to equip several universities with complete computing centers.

Ideas, anyone?

Bits

Now, having gotten my two-bits' worth off my chest concerning a problem which has been bothering me, I will give you bits of information about what you may expect in the rest of the *Newsletter* (if you've read this far).

First, under Pieces, there are excerpts from Hal Coleman's notes on the Midwestern Simulation Council meeting of 12 September at WADC. For your Ed., Hal's notes raised more questions than they answered, but this *Newsletter* has never claimed that it could give you all the answers, so perhaps Hal, who is reporting on a meeting for the first time, is right in the groove. He tells you who had something to say and on what subject. If you want details of what they said, perhaps you would be better off to get them firsthand by writing the people directly.

Then under information (without theory) there are some random comments concerning possible commercial availability of magnetic-tape dead-time simulators; a paper on "An Analog Computer Technique Using Magnetic Amplifiers" which seems to give one answer to the September *Newsletter* question about the use of logarithms for multiplication: some remarks on a new (to us) kind of precision potentiometer; and other incidental intelligence.

Then in closing, "Thots" presents an idea which will not interest everyone, but if you have read that far you might just as well go on to the end!

Pieces

MEETING OF THE MIDWESTERN SIMULATION COUNCIL

by H. B. Coleman (Bendix Aviation Corp., Detroit, Mich.)

The Midwestern Simulation Council meeting held at Wright Air Development Center, Ohio, on 12 September began with an election, in which *Jim Stone* (Battelle Memorial Institute) was elected Vice Chairman (to succeed automatically to the chairmanship in six months), and *Hal Coleman* was elected Secretary.

Dee Rhoner on Division

In the first paper Miss Dee Rhoner (Goodyear Aircraft Corp., Akron, Ohio) described computer techniques for division which yield several linear functions of x. Division by x, $1 + ax$, $1 - bx$, and $bx - 1$ using only a single servo multiplier and then using an electronic multiplier were described.

Miss Rhoner next discussed the operation $x^2/(x-y)$ and the extension of the previous techniques to demonstrate division by a function of two variables. The last points Dee covered were a circuit for the variation of nonlinear damping and the logarithm of a dependent variable.

Bob Howe (University of Michigan, Ann Arbor, Mich.) asked if the effect of drift had been investigated, to which Dee answered that this problem had not yet been evaluated.

At this point *W. G. Braun* (WADC) called the attention of the computer manufacturers to the fact that when a division circuit happens to divide by zero it is possible to put 200 volts across some of the potentiometers. As these pots are normally rated at 2 watts, he indicated that some form of protection should be considered. Dee commented that the variables she had been considering had not approached zero.

Bob Howe observed that the generation of logarithmic and trigonometric functions can be accomplished by attenuating integrator input by the rate of the variable, which caused *Roger Gaskill* (Willow Run Research Center, Ypsilanti, Mich.) to point out that the rates are not always available and that to obtain them would require additional equipment.

Milt Warshawsky (WADC) indicated that his demonstration later in the afternoon would show how they obtained derivatives.

Bob Howe remarked that in much missile work, particularly in coordinate transformation, the rates in question are available.

Estes on Simulation Techniques

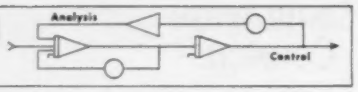
Next Bruce Estes (McDonnell Aircraft Corp., St. Louis, Mo.) discussed various simulation techniques employed by their organization. The first was a device for measuring the frequency response of components, using computer elements. With this technique it is possible to obtain the gain and phase shift of a device for a particular frequency by measuring a pair of potentiometers used in a nulling circuit.

The second technique was designed to save time in the simulation of transfer functions. For this, he showed a scheme of switching whereby with a single setup it would be possible to put in any or all of the terms of a quadratic divided by a quadratic. Any of the terms can be made zero or any appropriate value by potentiometer setting, amplifier gain, and switch position.

Generation of nonlinear functions such as hysteresis and backlash by use of diodes and batteries, and circuits for simulating coulomb friction and constant torque with dead space were then explained. Bruce concluded by showing three techniques for obtaining the absolute values of a variable using servos, diodes, and relays.

ARL-WADC

After intermission Braun discussed the facilities of the WADC Aeronautical Research Laboratory, in particular the patchboard verifier. This is a device which takes a Reeves patchboard, examines all of the pins, and writes out in coded form the connections between the leads. The technique involves a matrix which



indicates the location of the plug by row and column, and the number of the plug.

Because time was running short the meeting was closed and those present split into two groups—one toured the Flight Control Laboratory with Lieutenant *A. C. Robinson* and observed the operation of a Link Flight simulator representing an F-80. A television monitoring set was so placed that the visitors could view the control panel display in the Link cockpit. Also of interest, in addition to the regular 1:1 time-scale equipment, was the array of Philbrick equipment.*

Later the groups switched and the first group was taken to the Aeronautical Research Laboratory by *Milt Warshawsky*, who demonstrated a test circuit setup and its use on the REAC. A patch panel is set up to use all of the inputs and outputs of the amplifiers on a standard REAC in such a way that it gives a good quick check of the amplifiers and gains. The second trick which Milt displayed was a device for regulating sine and cosine oscillation. It involved the introduction of a perturbation which kept a sine-cosine oscillation at constant amplitude. The last stunt was the differentiation of an arbitrary function, which was an airplane cross-section area wired on a plotting board. This was differentiated by a lead-lag circuit.

Also displayed was the patchboard verifier which Braun had told us about.

---

*Dr. George A. Philbrick will tell you in no uncertain terms that the GAP/R is also 1 to 1 time-scale equipment.—ED.

Information (Without Theory)

Twenty-two representatives of 10 organizations met at Tullahoma, Tennessee on September 30th to organize the Southeastern Simulation Council. They selected *W. H. Bradley* (Murphy and Cota, Atlanta, Ga.) as Secretary, and decided to hold their next meeting under the auspices of Georgia Tech at Atlanta, Georgia, in connection with the IRE Instrumentation Conference and Exhibit, November 28-30. More on this organizational meeting in the next issue.

On Dead Times:

A letter from *Frank C. Smith, Jr.* of Southwestern Industrial Electronics Company (2331 Post Oak Rd., Houston 19, Tex.) says in part:

> "We are pursuing development of our magnetic-tape dead-time simulator in two forms, one for long time delays (more than 30 seconds), and one for short time delays (1/10 second to 30 seconds)."

We also spoke to *Gomer Davies* at the ISA Convention, and he indicated that his Davies Laboratories (4705 Queensbury Rd., Riverdale, Md.) has a tape device for the purpose.

On Logarithmic Networks:

In the *Simulation Council Newsletter* writeup of the Eastern Simulation Council discussion of analog multipliers, the question of using logarithmic devices for analog computing was raised. However, it seemed that no one knew much about it. Now we have a paper, "An Analog Computer Technique Using Magnetic Amplifiers," by *B. E. Davis* and *I. H. Swift* of NOTS, China Lake, Calif., which not only describes the use of magnetic amplifiers to gain high reliability for analog computing equipment, but which describes the use of logarithmic networks. This is AIEE paper No. 54-389.

We were interested to note that both magnetic amplifiers and logarithmic networks were used in the SIE "Flowmeter of the Future" displayed at the ISA Convention. Also of interest to us was the Tapot potentiometer (Howell Instrument Co., 1106 Norwood, Ft. Worth, Tex.) which seemed to consist of a wire glued to the back of a white tape which passed under a hair line in a window between two reels. The tape had individual calibration on it, which made for high accuracy, while the continuous rather than mandrel-wound resistance wire gave "infinite" resolution.

Thots (To Think About)

We have just received our National Simulation Conference General Announcement No. 2 from *Louis Wadel*, the General Chairman (3905 Centenary Drive, Dallas 25, Tex.), and are surprised and impressed with the number of papers of interest. More than half of the 34 papers to be presented at the Conference (which will take place in Dallas from 19 to 21 January 1956) are of unusual interest to us. And because we are interested in simulation we believe that they will be unusually interesting to anyone else interested in simulation.

Hence the "THOT": How about an inter-Council get-together of all Simulation Council members who can make the trip "deep in the heart of Texas"? It could be social (luncheon, cocktails, or dinner), technical (though I believe that the Conference will offer enough of that), or just a bull session on Council activities, problems, and plans.

If you will let your Ed. know your wishes, it can be arranged.

Computer Events

other events on page 1858

Eastern Simulation Council

Date: Monday, 21 Nov. 1955; 1:30 PM
Place: Massachusetts Institute of Technology, DACL Laboratory, Cambridge 39, Mass. Host: Dr. William Siefert, DACL, MIT.
Subject: "The Use of Digital Computers in Solving Simulation Problems."

Southeastern Simulation Council

Meeting will be held under the auspices of Georgia Tech in Atlanta, Ga., in connection with the IRE Instrumentation Conference and Exhibit, November 28-30.

Western Simulation Council

Date: 12 January 1956
Place: Ramo-Wooldridge Corporation, 5740 Arbor Vitae, Los Angeles 45, Calif.
Time: 1300
Subject (tentative): Noise—Analog-digital combinations

National Simulation Conference

Date: January 19-21
Dallas-Fort Worth Chapter of IRE Professional Group on Electronic Computers National Simulation Conference, Dallas, Texas. For information contact J. R. Forester, 2104 Huntington, Arlington, Texas.

High-Speed Computer Conference

Date: 14-17 February 1956
Place: Louisiana State University, Baton Rouge, La. For information write Dr. Leon C. Megginson, Department of Business Administration, Louisiana State U.

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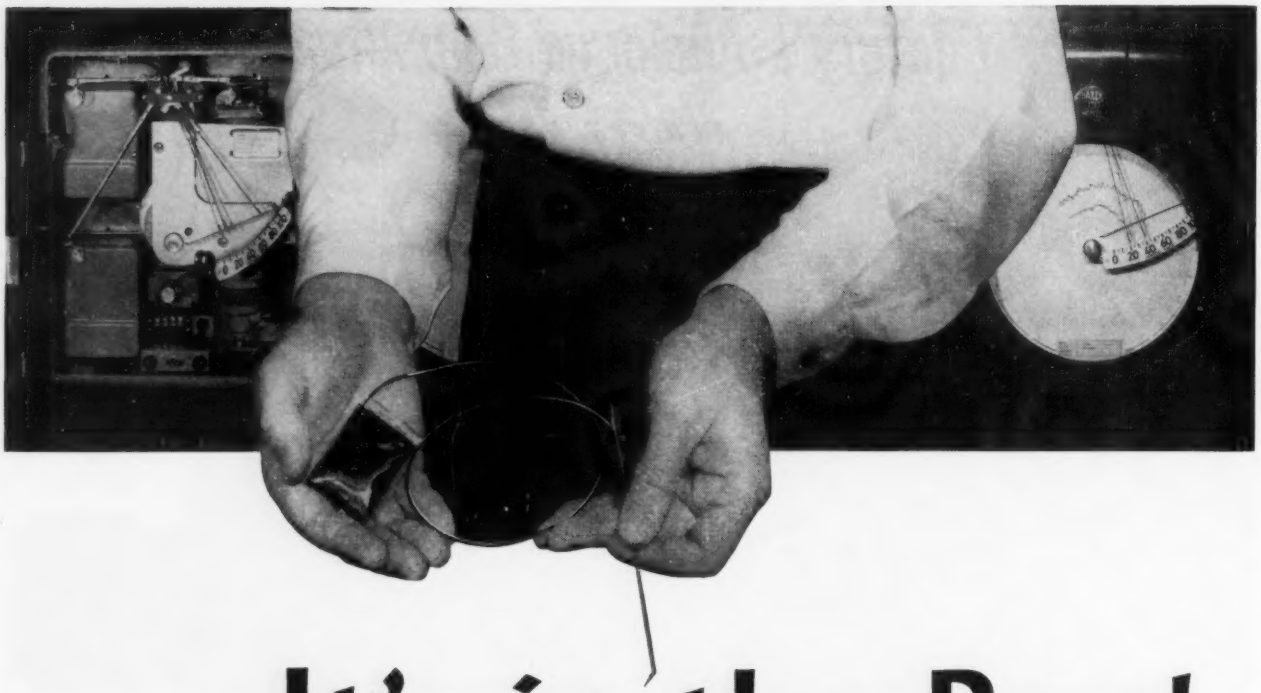

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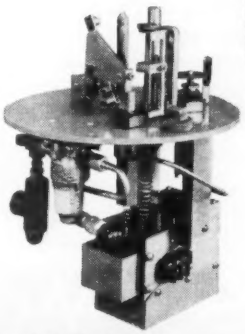

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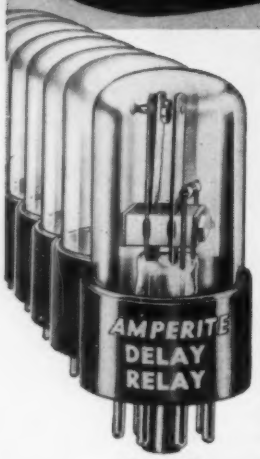

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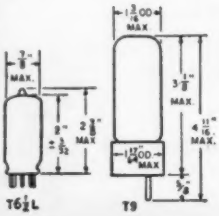

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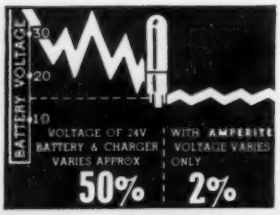

Write for 4-page Technical Bulletin No. AB-51

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Events...

November 28-30

Professional Group on Instrumentation, Atlanta Sec. of I.R.E. Instrumentation Conference, Biltmore Hotel, Atlanta, Ga. For information contact D. L. Finn, School of Electrical Engineering, Georgia Institute of Technology, Atlanta, Ga.

December 5-9

25th Exposition of Chemical Industries, Commercial Museum and Convention Hall, Phila., Pa. For information write International Exposition Co., 480 Lexington Ave., N.Y. 17, N.Y.

December 14

Phila. Sec. IRE, Del. Valley Sec. SIAM, and Professional Group on Engineering Management IRE will present a One-day Operations Research Symposium, University Museum, University of Pennsylvania, Phila., Penna. For information write R.V.D. Cambell, O.R. Symposium Reg., Burroughs Research Center, Paoli, Penna.

January 9-10

Second National Symposium on Reliability and Quality Control in Electronics, Hotel Statler, Washington, D. C. For information contact V. Wouk, Beta Electric Corp., 333 E. 103rd St., New York 29, N. Y.

January 19-21

Dallas-Fort Worth Chapter of IRE Professional Group on Electronic Computers National Simulation Conference, Dallas, Texas. For information contact J. R. Forester, 2104 Huntington, Arlington, Texas.

January 25-27

Eleventh Annual Conference on Instrumentation for the Process Industries, sponsored by Chemical Engineering Dept., Texas A&M, will be held on campus. For information write Chemical Engineering Dept., Texas A&M, College Station, Texas.

February 15-17

Third Conference on High-Speed Computers will be held on campus, Louisiana State University, Baton Rouge, La. For information write J. W. Brouillette, General Extension Div., Louisiana State U., Baton Rouge 3, Louisiana.

March 18-24

Consecutive Meetings and Co-Exhibit of American Congress on Surveying and Mapping and the American Society of Photogrammetry, Shoreham Hotel, Washington, D. C. For information write ACSM-ASP, Box 470, Washington 4, D. C.

April 5-6

Special Technical Conference on Magnetic Amplifiers, cosponsored by AIEE Committee on Magnetic Am-

plifiers, IRE Professional Group on Industrial Electronics and ISA Central New York Sec., Hotel Syracuse, Syracuse, N. Y. For information write Charles F. Spitzer, General Electric Co., Bldg. 3, Electronics Park, Syracuse, N. Y.

May 14-17

The Physical Society 40th Exhibition of Scientific Instruments and Apparatus, Royal Horticultural Society's Halls at Westminster. For information write Exhibition Secretary, 1, Lowther Gardens, Prince Consort Rd., London, S.W. 7, England.

June 6-8

American Society for Quality Control 10th Annual Convention and Exhibit, Palais Du Commerce, Montreal, Canada. For information write Charles R. Kendel, Lamson & Sessions Co., 1971 West 85th St., Cleveland 2, Ohio.

June 17-22

American Society for Testing Materials 59th Annual Meeting and 12th Apparatus Exhibit, Chalfonte-Haddon Hall, Atlantic City, N. J. For information write Fred F. Van Atta, ASTM, 1916 Race St., Phila. 3, Penna.

September 15-23

Fourth International Instruments and Measurements Conference and Exhibition, organized by the Royal Academy of Engineering Sciences and the Swedish Association of Technical Physicists, will be held in Stockholm, Sweden. For information write Sven Malstrom, P. O. Box 12035, Stockholm 12, Sweden.

September 16-22

American Society for Testing Materials 2nd Pacific Area National Meeting and Apparatus Exhibit, Hotel Statler, Los Angeles, Calif. For information write Fred F. Van Atta, ASTM, 1916 Race St., Phila. 3, Penna.

September 24-28

Joint committee for Automatic Control of the German Association of Electrical Engineers (VDE) and German Engineers Society (VDI) Conference on Automatic Control will be held in Heidelberg. For information write Verein Deutscher Electrotechniker (VDE) Osthofenplatz 6, Frankfurt 2/main, West Germany.

November 26-30

Third International Automation Exposition, New York Trade Show Building, 500 8th Ave., New York, N. Y. For information write Richard Rimbach Associates, 845 Ridge Ave., Pittsburgh 12, Penna.

HAGEN
Synchronous motors

most powerful for its size

Laminated rotor construction of the Model 50 Hagen Motor produces exceptionally high torque. For example, the rotor develops 10 ounce inches torque at 4 RPM. This motor is ideal for those applications requiring from 5 to 10 times the power of clock-type miniature motors. Yet in spite of its power, the motor is extremely compact:

DIMENSIONS

	50 to 60 cycle	25 cycle
A	3-3/32	3-1/16
B	1-13/32	1-23/32

Just a few of the many possibilities for use are: door chimes, laundry timers, depth finders, animated displays, heating controls, program clocks, fire alarm systems, integrators, time switches, chart drives, scoreboards, potentiometer drives. Motor may be mounted in any position. Wide selection of output speeds from 1800 to 1/6th RPM. Reversible and other models available. Send coupon for Bulletin No. 1055.

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Dept. IA-1155, Moline, Illinois

Please send Bulletin 1055 on Hagen Synchronous Motors.

NAME AND TITLE

COMPANY

ADDRESS

CITY ZONE STATE

For more information circle **58** on inquiry card.

New Instruments...

INSTRUMENTS and AUTOMATION

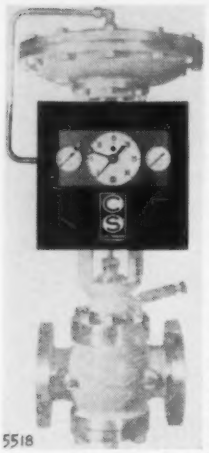
PROCESS CONTROL AND MONITORING

Miniature Potentiometer

New miniaturized version of "Dynamaster" self-balancing potentiometer, available in indicating, recording and controlling forms, occupies panel area 5" square, can be used to measure flow-rate, speed, pH, temperature, etc., as well as electrical measurables; comprises two cases: miniature case mounted on panel contains balancing motor with its indicating pointer or recording pen, measuring circuit and slide-wire, and amplifier; second case (mounted on panel or in back of it) contains preamplifier, "Syncroverter" and standardizing mechanism.—*The Bristol Company, Waterbury* 20, *Conn.*

For more information circle **201** on inquiry card.

Pressure or Temperature Controller



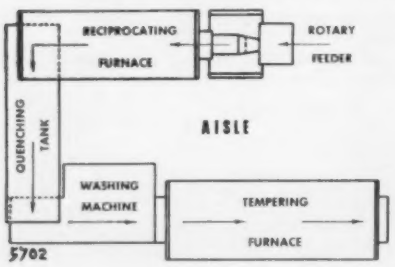
5518

New "Type 51 Pilot" is applicable for automatic control of pressures from 0-15 to 0-10,000 psig, 0-30" water and 0-30" Hg vacuum; and of temperatures in ranges from −40°F to 1000°F. Among features: process pressure or temperature gage; calibrated set point adjustment; 1 to 100% proportional band and differential gap; availability with proportional plus automatic reset action; frictionless power relay with sapphire nozzle and pushbutton cleaner. Available by itself or mounted on control valve.—*A. W. Cash Co., P. O. Box* 551, *Decatur, Illinois.*

For more information circle **202** on inquiry card.

Automatic Heat-treating

New completely automatic continuous heat-treating installations have production capacities from 100 to 800 lbs./hr. Each installation can be made either in-line or in a "reversing loop" as illustrated. Flexibility permits handling small as well as large production lots on a continuous basis. Versatility permits clean hardening, light case carburizing, etc., without any modification.—*American Gas Furnace Co.,* 586 *Lafayette St., Elizabeth, N. J.*



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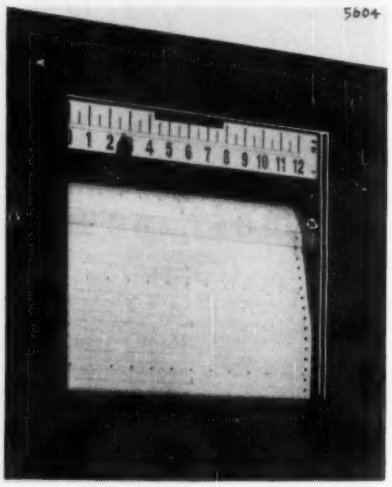
For more information circle **203** on inquiry card.

Multiple-range Recorder

New "Model 39" multiple-range strip-chart recorder automatically switches from one to next in a series



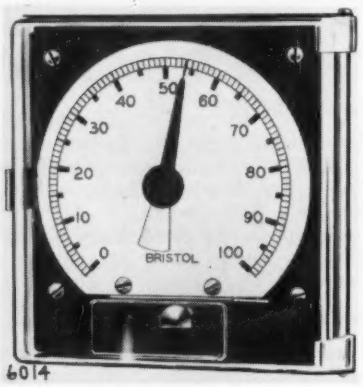
5604

of full-scale ranges of 0-110, 100-210 and on up to 900-1010 mv.; is particularly suitable for recording small voltages or currents with high accuracy over wide ranges. Range switching is performed by limit switches at both ends of recorder slidewire, so that next-higher or next-lower range is automatically selected when recorder pen reaches either end of scale. Among obvious applications: thermocouples, electrometers, etc.—*Applied Physics Corp.,* 362 *W. Colorado St., Pasadena, Calif.*

For more information circle **205** on inquiry card.

Miniature Indicating and Recording Receivers

New miniaturized "Metameter" telemeter receivers, available either as indicators (shown) or strip-chart



6014

recorders, occupy 5" x 5" panel space; receive telemetered signals of pressure, flow, temperature, etc., as well as of voltage, current, and power. Being identical in appearance to "Metagraphic" pneumatic instruments, they make for uniformity of graphic or conventional panels.—*The Bristol Company, Waterbury* 20, *Conn.*

For more information circle **206** on inquiry card.

Automatic-control Panels

New control panels for automatic operation of all types of equipment can be made to specification for original-equipment application or on-the-job requirements; feature improved circuitry designed to insure reliability; are available as open-type or enclosed in explosion-proof water-tight and drip-proof cabinets—all meeting J.I.C. recommendations.—*Dep't IUP, Industrial Control Panel Co.,* 517 *W. Monroe St., Chicago* 6, *Ill.*

For more information circle **204** on inquiry card.

5745

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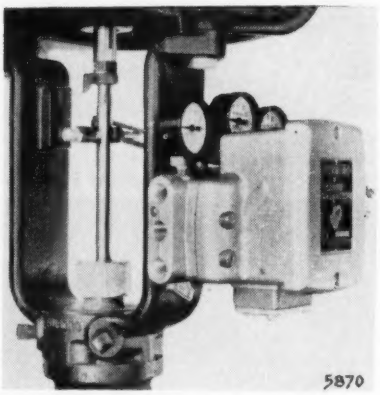
FOR FURTHER INFORMATION use the postage-free order card on page 1979

Valve Positioner

New "Type C Vernier Valvactor" utilizes motion-balance principle to overcome friction and minimize line effects. Among applications: large-volume diaphragm motors and long controller-to-valve distances. Princi-

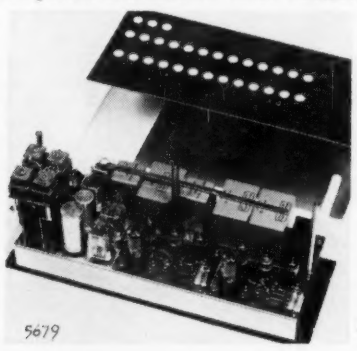


ple: positioner receives controller output signal at a spring-opposed bellows which governs a flapper-nozzle relationship. Back pressure in nozzle circuit acts on a high-capacity air relay to vary supply pressure to valve motor. Full pressure can be applied to motor on a signal change of less than 2" of water. Movement of valve stem to its correct position rebalances flapper-nozzle relationship.—*The Foxboro Co., Foxboro, Mass.*

For more information circle **207** on inquiry card.

Phone-channel Terminal for Control Signals

New "Model 983 Voicon Terminal," for transmission and reception of control signals over an in-use telephone channel without impairing speech quality, is applicable to microwave and power-line-carrier voice channels



☆ ☆ DUBROVIN ☆ ☆
VACUUM GAUGES

Compact Practical Gauges For Moderately Reduced Pressures

•

Range: 0.2 mm To 20 mm of Hg

•

Far More Sensitive Than Mercury Manometer

•

Two Sensitivities Available

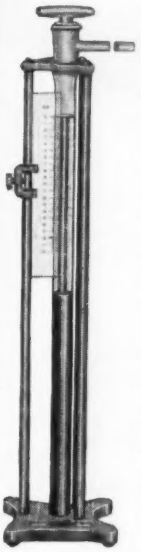
•

Pyrex-Brand or Soft-Glass Construction

•

Table or Wall Mounting

The Dubrovin Gauge indicates the pressure continuously, may be left in the system indefinitely, and is not damaged if the line is suddenly opened to atmospheric pressure. It is simple to install and convenient to use. A typical application for which it has proved especially convenient is the filling of tubes with gas at a specified pressure, as in the luminous-tube industry. It is useful wherever a sensitive gauge of this range is needed.

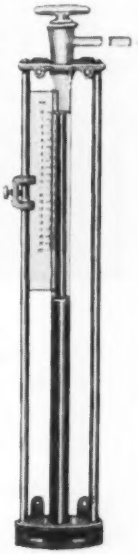


No. 1451C Table Mounting

There are two basic types, one 9 times and the other 6 times as sensitive as a mercury manometer. Because of this "magnifying factor", the gauge is as sensitive as a manometer which uses a liquid of low density, but has the advantage of using mercury which dissolves very few organic or inorganic vapors and which requires no conversion factor. Unlike mechanical or optical magnifying devices, any small errors due to capillarity, adhesion, etc., are not magnified. The smallest division on the 9-to-1 type is 0.2 mm and on the 6-to-1 type is 0.5 mm of Hg. Fractions of these values may be estimated. Both types are available with Pyrex-brand or soft glass in either a table or wall mounting.

The Dubrovin Gauge consists of a stainless-steel cylinder, of small diameter and closed at one end, floating vertically in mercury with its open end submerged and with the air evacuated from the chamber thus formed. The outer tube, in which the cylinder and mercury are enclosed, is of glass mounted in a metal frame and connected to the vacuum line. An adjustable scale on the metal frame is read by an indicator at the top end of the floating cylinder.

To set up, the gauge is first evacuated by a good mechanical pump to about 1 micron while being supported on its side so that air will be removed from the floating cylinder. It is then set upright and the scale adjusted until the index reads zero. The gauge may then be opened to atmospheric pressure and installed in any vacuum line, care being taken not to incline it such that air re-enters the float.



No. 1451H. Wall Mounting

Cat. No.	Pressure Range mm of Hg	Magnifying Factor	Merc. Req'd, Lbs.	Material of outer tube	Mounting	Each
1451C	0.50 to 20	6	1	soft glass	Table	$44.50
1451D	" " "	"	"	Pyrex Brand	"	44.50
1451G	" " "	"	"	soft glass	Wall	44.50
1451H	" " "	"	"	Pyrex Brand	"	44.50
1451E	0.2 " "	9	2¼	soft glass	Table	52.50
1451F	" " "	"	"	Pyrex Brand	"	52.50
1451J	" " "	"	"	soft glass	Wall	52.50
1451K	" " "	"	"	Pyrex Brand	"	52.50

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1515 Sedgwick Street, Dept. B Chicago 10, Illinois, U. S. A.
Manufacturers of Scientific Instruments and Laboratory Apparatus

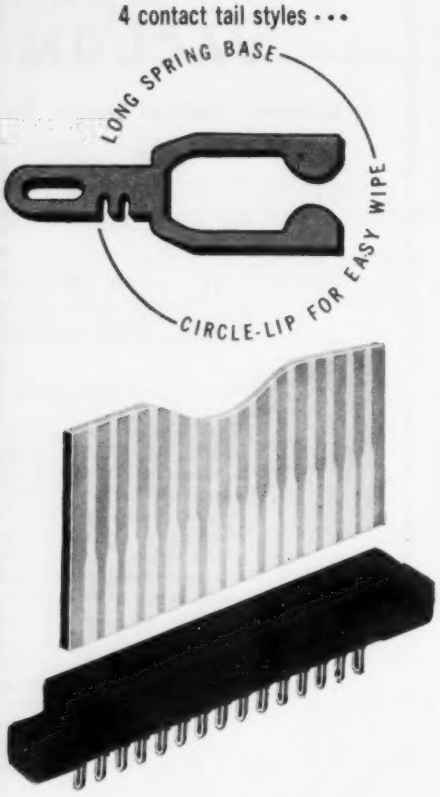
For more information circle **59** on inquiry card.

AMPHENOL

PRIN-CIR
CONNECTORS

revolutionary
NEW
contact design

IN
AMPHENOL
PRINTED CIRCUIT
CONNECTORS



Prin-Cir connectors are the result of careful design work by AMPHENOL Development Engineering. They feature compact bodies and a new contact design that is greatly superior to any available for printed circuit applications.

Prin-Cir contacts can't be set, can't be overstressed when used with standard .061" to .071" boards, have very low millivolt drop and extremely long life. This contact has an extra-long spring base and a circle-lip for good wiping action.

Prin-Cir connectors are available with 10, 15, 18 and 22 contacts in four contact tail styles: Standard Eyelet, Wire Wrap, Pin and Open End. They may be ordered with one or more polarizing keys in any contact location.

Bodies are molded of an improved version of AMPHENOL blue dielectric and contacts are gold-plated.

AMERICAN PHENOLIC CORPORATION
chicago 50, illinois

In Canada:
AMPHENOL CANADA LIMITED, *Toronto*

AMPHENOL

Write for special Product Bulletin!

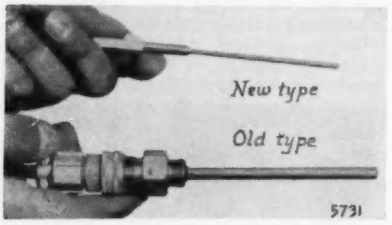
as well as those derived on physical pairs.—*Radio Frequency Laboratories, Inc., Powerville Rd., Boonton 14, N. J.*

For more information circle **208** on inquiry card.

TEMPERATURE and HUMIDITY

Platinum Resistance Thermometer Bulbs

New platinum resistance thermal elements featuring 0.6% accuracy and high-speed response can be ap-



plied to temperature ranges from 330°F to 1380°F; are hermetically sealed in either 7/32" diam Pyrex or 1/16" diam ceramic housings. For use in pyrogen testing or general laboratory work, elements are mounted in a ⅛" smooth stainless steel case with all leads protected by pliable rubber tubing.—*Fielden Instrument Div., Robertshaw-Fulton Controls Co., 2920 N. 4th St., Philadelphia 33, Pa.*

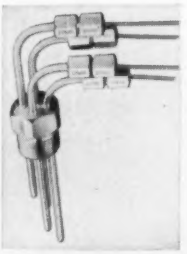
For more information circle **209** on inquiry card.

Thermometer Pigment

New "Permafused" pigment used in maker's etched-stem mercury-filled thermometers is fused into thermometer glass, becomes part of the glass itself; is impervious to boiling organic solvents and all acids except those which attack glass. Color: deep reddish brown.—*Taylor Instrument Companies, Rochester 1, N. Y.*

For more information circle **210** on inquiry card.

Gradient-check Well



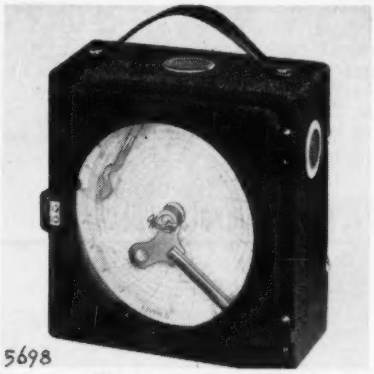
New "Multiple Speedwell" for checking temperature gradients provides temperature readings at 2, 3, 4 or 5 points simultaneously from one vessel wall entrance. Small stainless steel protection tube (3/16" diam by 0.035" wall) and butt-welded couple bottomed in well give rapid response. Simplicity of maker's exclusive packing glands permits rapid installing, changing or removing TC elements. Operating ranges: pressures from full vacuum to 3000 psi and temperatures from −300°F to +2000°F. Safety: in event of tube failure under high pressures, seals at top of wells will hold system pressure.—*Conax Corp., 7811 Sheridan Drive, Buffalo 21, New York.*

For more information circle **211** on inquiry card.

← Circle **60** on inquiry card.

Miniature Temperature Recorder

New "Model 8465" improved high-sensitivity bimetal-actuated miniature recorder, with rapid range-changing

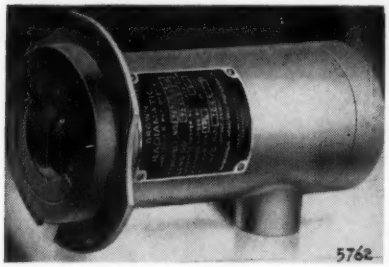


feature, will operate accurately in any position; is unaffected by atmospheric pressure changes; withstands severe transportation service.—*Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.*

For more information circle **212** on inquiry card.

Radiation Receiver

New version of maker's "Radiamatic" is said to be five times faster than existing models." It responds to

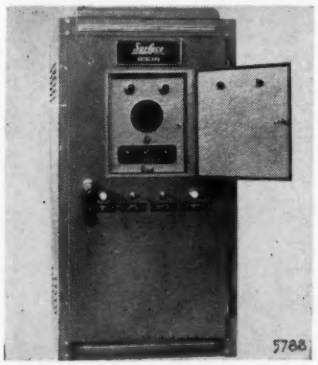


98% of any temperature change in less than a half-second. Three models: One has a narrow sighting angle (20:1 ratio) for intermediate temperatures, covering range from 800 to 1900°F. Other models have either a narrow angle (20:1 ratio) or a wide angle (7:1 ratio); both cover high temperature range from 1000 to 2600°F.—*Minneapolis-Honeywell Regulator Co., Philadelphia 44, Pa.*

For more information circle **213** on inquiry card.

Dewpoint Controller

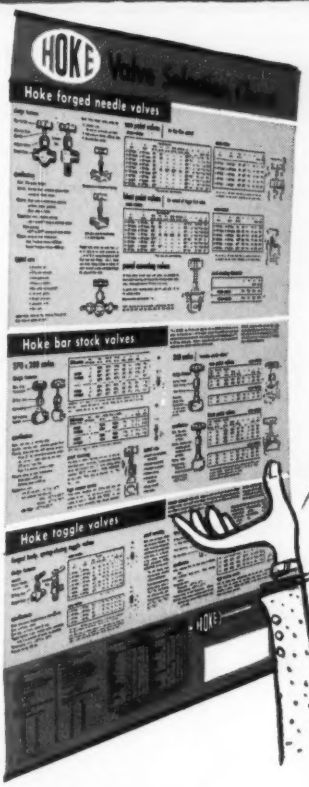
New automatic controller, added to "Autocarb" carbon potential control systems, provides a simple and economical means of automatically controlling the dewpoint of an atmos-



HOKE

Flow Sheet

Hoke reports on fluid control



IT'S A SNAP!

. . . to select the small valves you need when you have Hoke's new Valve Selection Chart hanging nearby. You'll be pleased as can be with this simplified method for picking out the proper forged needle valve, bar stock valve, or spring-closing or cam-closing toggle valve from this big (18" x 24") wall chart . . . They're all cataloged for you with dimensional and performance data to simplify your selection, including a Corrosion-Resistance Table for proper valve material choice and the method to be used (with formulae) for determining the proper valve size. Hoke Valve Selection Charts are now available. Just write to us, we'll be happy to fill your request.

P.S. *There's another way to simplify your selection of Hoke Valves . . . that's by visiting us in Booth 935 at the Chemical Industries Exposition, Dec. 5th to 9th, in Philadelphia's Commercial Museum. We'd like to show you the many outstanding features of all of Hoke's fluid control products.*

HOKE

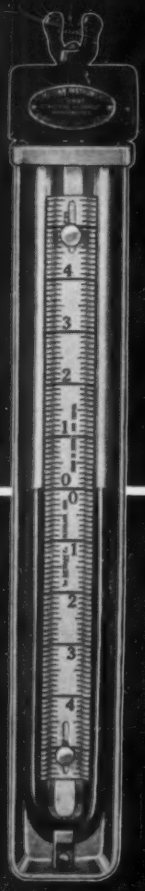
HOKE INCORPORATED

Fluid Control Specialists

For more information circle **61** on inquiry card.

UNMATCHED ACCURACY

with simplicity / and economy



AT LOWEST COST . . . this Meriam Manometer offers high accuracy. The Meriam B-1103 is the easy-to-use, always dependable form of pressure or flow instrumentation. Pressures to small fractions of an ounce are read directly, accurately . . . without calibration or instrument adjustment . . . with complete enduring manometer reliability.

★ Rugged cast alloy construction

★ Convenient manometer cleanout

★ Curved scale for increased readability

★ Designed for easy panel mounting

Write for Bulletin C-12.

Meriam Manometer Instrumentation
...for pressures, vacuums, flows, liquid levels.

meriam
INSTRUMENT COMPANY
10920 Madison Ave. - Cleveland 2, Ohio

For more information circle **62** on inquiry card.

NEW INSTRUMENTS

phere generator, or a heat treat furnace; it is applicable to processes where a permanent record is not required.—*Surface Combustion Corp., Toledo* 1, *Ohio.*

For more information circle **214** on inquiry card.

Sling Psychrometer

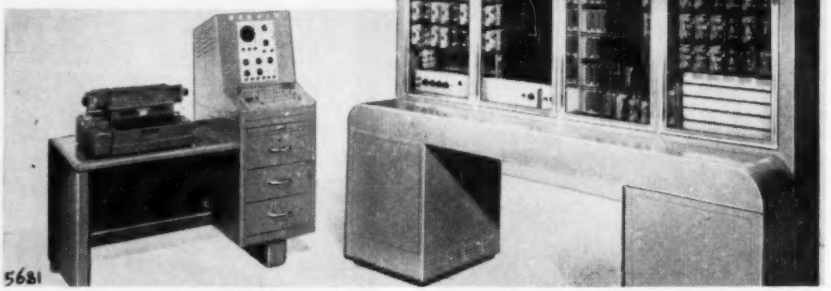
New 9" long model of maker's sling psychrometer has several features which make it much easier to use than previous models: (1) thermometer tubes of "Gold Back" design for greater contrast and easier reading; (2) sturdy protective back finished in gray baked gun-metal synthetic enamel for increased contrast; (3) redesigned handle, rigidly attached to metal back, folds out of way when not in use.—*Taylor Instrument Companies, 95 Ames St., Rochester* 1, *N. Y.*

For more information circle **215** on inquiry card.

COMPUTING and DATA HANDLING

General-purpose Computer

New "Readix" low-cost computer is designed for scientific computation, data reduction and automatic-control systems (as well as business data processing). It is of the digital, one-address, stored-program class. Among features: fixed and floating point operation; alpha-numeric input and output; all-decimal internal operation; five types of input; five types of output; simplified program techniques; 4000-word internal memory; minimal maintenance costs. —*J. B. Rea Co.,* 1723 *Cloverfield Blvd., Santa Monica, Calif.*



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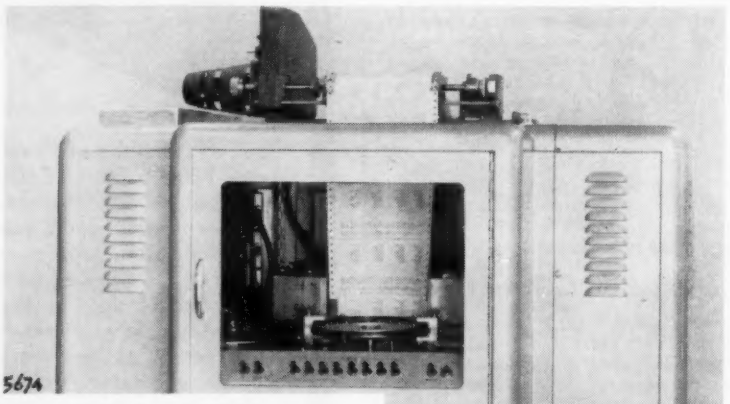
For more information circle **216** on inquiry card.



5674

High-speed Data Printer

New model of "Flying Typewriter" has a magnetic core memory storage which reduces number of electron tubes in printer to fewer than 300 and increases printing speeds to 600 alpha-numeric (or 1200 strictly numerical) characters per second. Maker's "Magnetic Tape Handler" is included as standard equipment to utilize speed capabilities; but data can be fed from punched or perforated tape handlers or directly from a high-speed digital computer.—*Potter Instrument Co.,* 115 *Cutter Mill Rd., Great Neck, L.I., N. Y.*

For more information circle **217** on inquiry card.

NEW BULLETIN P355G

There's a **Powerstat** to meet your Every Need!

powerstat

variable transformers

Bulletin P355G

a product of THE SUPERIOR ELECTRIC COMPANY Bristol, Connecticut

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Send for this New Bulletin Today

SALES OFFICES: The Superior Electric Company

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Fred N. Haight Co., 3212 Eastlake, Seattle 2, Wash.

The Superior Electric Company

711 Reynolds Avenue, Bristol, Conn.

Please send me POWERSTAT Bulletin P355G

Name.....

Position.....

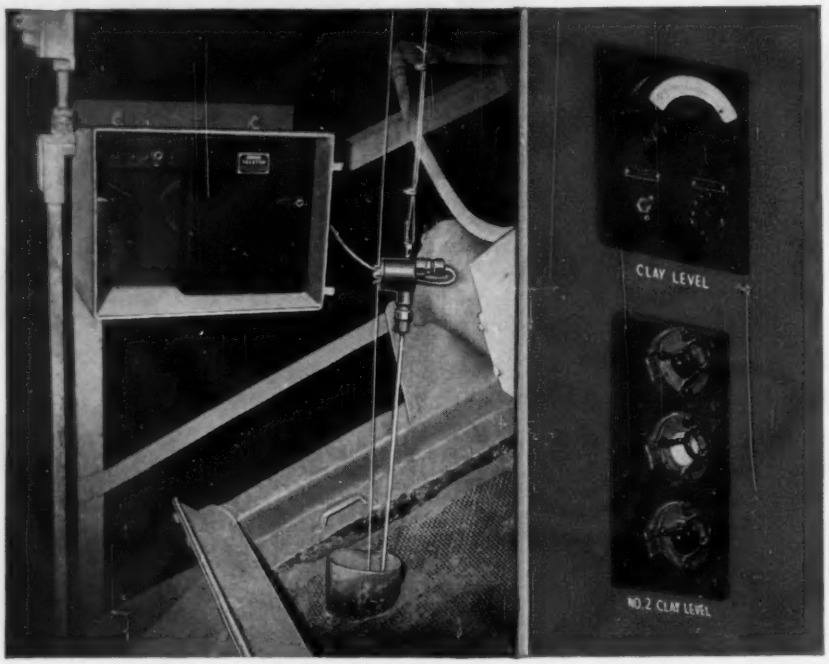
Company Name.....

Company Address.....

City.....*Zone*.....*State*.....

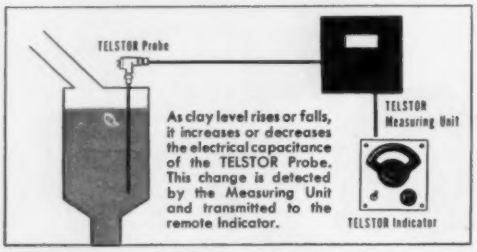
For more information circle **63** on inquiry card.

At Magnolia Petroleum TELSTOR Saves Operator Time and Clay



A Fielden TELSTOR System now enables operators at Magnolia Petroleum Co., Beaumont, Texas, to keep tabs on spent clay as it flows from a lube oil filter to a storage hopper to a revivifying kiln.

Because of its ability to measure all types of material and catalysts, TELSTOR shows clay level in the hopper with good accuracy. Its simple and completely safe electronic system is unaffected by the clogging nature of the oil-saturated clay. Send the coupon today for more facts about TELSTOR.


TELSTOR Probe
As clay level rises or falls, it increases or decreases the electrical capacitance of the TELSTOR Probe. This change is detected by the Measuring Unit and transmitted to the remote Indicator.
TELSTOR Measuring Unit
TELSTOR Indicator

TELSTOR Features

- For liquids, liquid interface, powders, granular solids (conducting or non-conducting).
- Measures spans up to 200 feet or any portion.
- Maximum pressure 1000 psi (350° F.); maximum temperature 750° F. (150 psi).
- No moving parts—only one radio tube.

Robertshaw-Fulton
CONTROLS COMPANY

FIELDEN INSTRUMENT DIVISION
Dept. A, 2920 N. 4th St., Philadelphia 33, Pa.

Please send me bulletins describing:
- ☐ TELSTOR Continuous Level Indicator
- ☐ TEKTOR Level Limit Control
- ☐ FIELDEN MULTI-POINT Recorders
- ☐ TEKTOLOG Recorders
- ☐ FIELDEN NULL-BALANCE Recorders

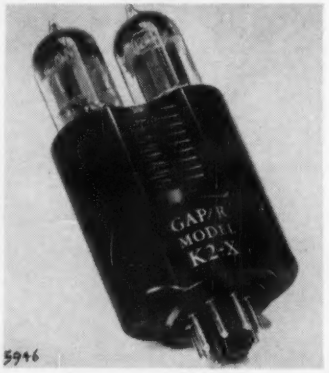
NAME _____ TITLE _____
COMPANY _____
STREET _____
CITY _____ ZONE _____ STATE _____

For more information circle **64** on inquiry card.

NEW INSTRUMENTS

Computer Amplifier

New "Model K2-X Operational Amplifier," added to maker's line of electronic analog components, features balanced differential inputs for minimal drift and maximal utility, high

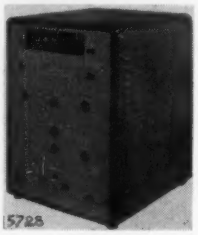


performance and economy of operation. Among its feedback operations are addition, subtraction, integration, differentiation, proportioning, inversion, impedance-conversion and injection of current. Gain: 30,000 dc open-loop; power requirements: 7.5 ma at +300 vdc, 5.2 ma at −300 vdc.—*George A. Philbrick Researches, Inc.*, 230 *Congress St., Boston* 10, *Mass.*

For more information circle **218** on inquiry card.

Data Translator

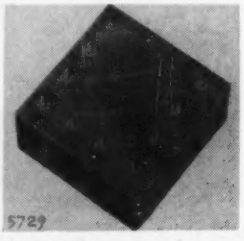
New "Model E Datrac," for precision voltage-to-digital and digital-to-voltage conversion, provides two voltage-to-digital conversions per second or thirty digital-to-voltage conversions per second; includes a visual readout and output conversion for direct control of printers, typewriters, or card punching equipment. Three floating decimal ranges provide full-scale readings of ±99.999, ±9.9999, and ±0.99999 v, whence 10-uv sensitivity.—*Epsco, Inc.*, 588 *Commonwealth Ave., Boston* 15, *Mass.*



For more information circle **219** on inquiry card.

Magnetic Storage Element

New "Type SR11" is an extremely low-power medium-frequency subminiaturized magnetic storage-ele-



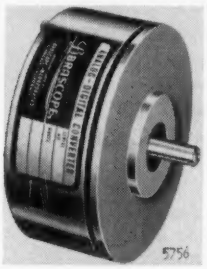
ment suitable for mounting on etched wiring boards. Wide operating limits and encapsulated packaging contribute to reliable performance. Unit is intended for airborne and missile ap-

plications; can be driven by subminiature tubes; is adaptable for transistor operation. Exceptional design feature is high ratio of storage elements to drive tubes.—*Epsco Inc.*, 588 *Commonwealth Ave., Boston* 15, *Mass.*

For more information circle **220** on inquiry card.

Analog-digital Converter

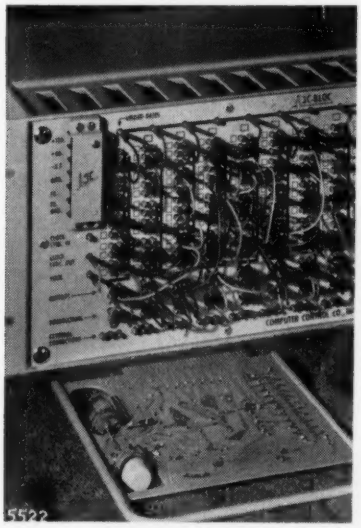
New shaft-position converter translates position of input shaft into Gray binary-digital code, assuring unambiguous translation of information from commutator-type code disc, whose eight rings contain 256 segments (resolution of 2^8) and provide a range of coded numbers from 1 to 255. Converter withstands shock to 20 *G*; functions dependably at −50°C to 85°C.—*Librascope, Inc.*, 808 *Western Ave., Glendale, Calif.*



For more information circle **221** on inquiry card.

Computer Building-block

New "3C-Bloc" high-speed component for digital computers, logical analyzers, simulators, and automation systems, can perform nearly all digital operations, including arithmetic computation, storage, programming, and logical decision, at 1-Mc pulse repetition rate. It comprises 15 gating packages and one synchronizing "clock" package.—*Computer Control Co., Inc.*, 92 *Broad St., Wellesley* 57, *Mass.*



For more information circle **222** on inquiry card.

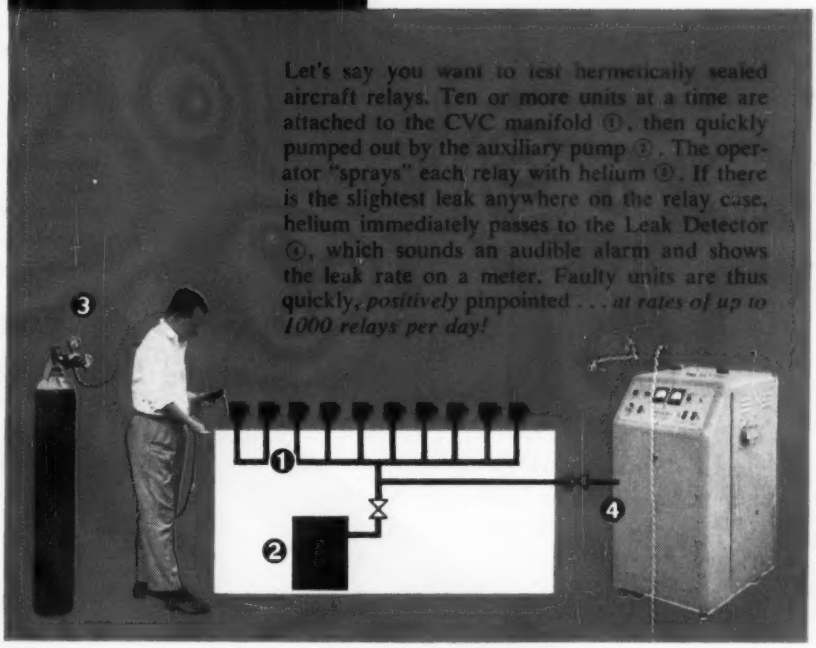
Counter-converter Unit

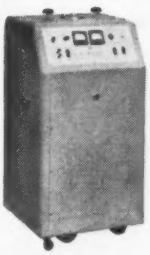
New computing component combines a basic counting facility and data reduction converter. Accepting regular or random digital information up to 100,000 events per second, unit has illuminated electronic scale display; can be used as two independent 3-digit counters or the flick of a switch makes it a single 6-digit counter. It provides contact closures to operate IBM type summary punches. Reset either manually or automatically, it has provision for a plug-in

POSITIVE LEAK TESTING.. CEC's Leak Detector makes it practical

If your product needs positive protection against the ravages of moisture, dust, high altitude, corrosion, and arcing, there's one *sure* protection against them all . . . hermetic sealing and testing with a CEC Leak Detector and a Consolidated Vacuum manifold system. Proven and practical, engineered to work together, they locate leaks *undetectable by any other method.*

Fast, simple, sure . . . Here's how CEC leak detection works


Let's say you want to test hermetically sealed aircraft relays. Ten or more units at a time are attached to the CVC manifold ①, then quickly pumped out by the auxiliary pump ②. The operator "sprays" each relay with helium ③. If there is the slightest leak anywhere on the relay case, helium immediately passes to the Leak Detector ④, which sounds an audible alarm and shows the leak rate on a meter. Faulty units are thus quickly, *positively* pinpointed . . . *at rates of up to 1000 relays per day!*
3
1
2
4



Now, two CEC leak detectors

The standard Type 24-101A detects one part of helium in 200,000 parts of air . . . measures leak rates to 10^{-9} std cc/sec. The new ultra-sensitive Type 24-110 detects one part of helium in *2,000,000 parts of air!* It is valuable, for example, in atomic-reactor equipment and in the production of "reliable-type" electron tubes. Send for Bulletin CEC 1801D-X13.

Consolidated Engineering *Corporation*

ELECTRONIC INSTRUMENTS FOR MEASUREMENT & CONTROL

300 North Sierra Madre Villa, Pasadena 15, California

Sales and Service Offices Located in: Albuquerque, Atlanta, Boston, Buffalo, Chicago, Dallas, Detroit, New York, Pasadena, Philadelphia, San Francisco, Seattle, Washington, D. C.

For more information circle **65** on inquiry card.

Now an 8½" x 11"

FLAT BED

X-Y recorder

with **0.25%** *accuracy and* **8** *other outstanding* **NEW** *features found in no other X-Y recorder*

Now you can have the advantages and convenience of flat-bed presentation in an 8½" x 11" X-Y recorder. Unique design and manufacturing techniques of the new Electro Instruments' recorder, developed after extensive research into what the industry wanted, make it the first really new recorder in years *and your best buy!*

8½" x 11" flat bed—Complete plot is always visible during plotting operation. Plot can be marked or identified *in place!*

Full-pad loading—Pen assembly adjusts to accommodate any pad thickness.

Plot paper easily changed—Simple switch control removes pen and arm from the plotting area. Tearing plot from pad exposes fresh paper.

½-second full scale pen speed—New servo design gives high performance.

New design minimizes "jitter"—New circuits eliminate 60- and 120-cycle pickup, effectively eliminating pen "jitter," and greatly improve performance of the recorder with noisy signals.

Convenient size—Compact package conserves lab space. Light weight makes it easy to move from one test position to another.

Unitized packaging—Engineered for quick accessibility and to facilitate ease of maintenance and replacement of parts. Only stock potentiometers are used.

Simple, accessible control panel—Recessed controls prevent damage from rough handling and accidental jarring or moving of controls during use.

11 scale ranges—5 mv to 500 volts full scale.

PLUS

these important proven features

Proven cable-drive—Assures reliable operation.

Quality components throughout—Precision wirewound resistors are especially aged and encapsulated for maximum reliability.

High input impedance—200,000 ohms per volt.

Potentiometer input by switch control

Your E-I representative has complete information, including prices and specifications. A phone call or letter will start him thinking about your problem. Contact him today.

ELECTRO INSTRUMENTS INC.

3794 Rosecrans Street
San Diego 10, California

For more information circle **66** on inquiry card.

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Contact your closest E-I representative today.

For more information circle **66** on inquiry card.

NEW INSTRUMENTS

time-base assembly which permits automatic recycling and "EPUT meter" operation.—*Harper Engineering Co., 2330 Michigan Ave., Santa Monica, Calif.*

For more information circle **223** on inquiry card.

Digital Indicator-sender

New "Type 33-110 SADIC Digital Voltmeter" has sensitivity of 10 mv for full-scale digital output (999). Controls permit selection of any voltage in either of two ranges (10 to 25 and 20 to 50 mv) for full-scale readout. Digital output is available for operation of automatic typewriters, punches, etc.—*Consolidated Engineering Corp., Pasadena 15, Calif.*

For more information circle **224** on inquiry card.

5618

Punch Tape Unit

New "Automatic Punch Tape Unit" for integrated data processing yields a high-speed 5-to-8-channel punched paper tape from a modified Clary adding machine; perforates tape at rate of 20 characters per second. Programming is dictated by uses desired of tape.—*Electronics Div., Clary Corp., San Gabriel, Calif.*

For more information circle **225** on inquiry card.

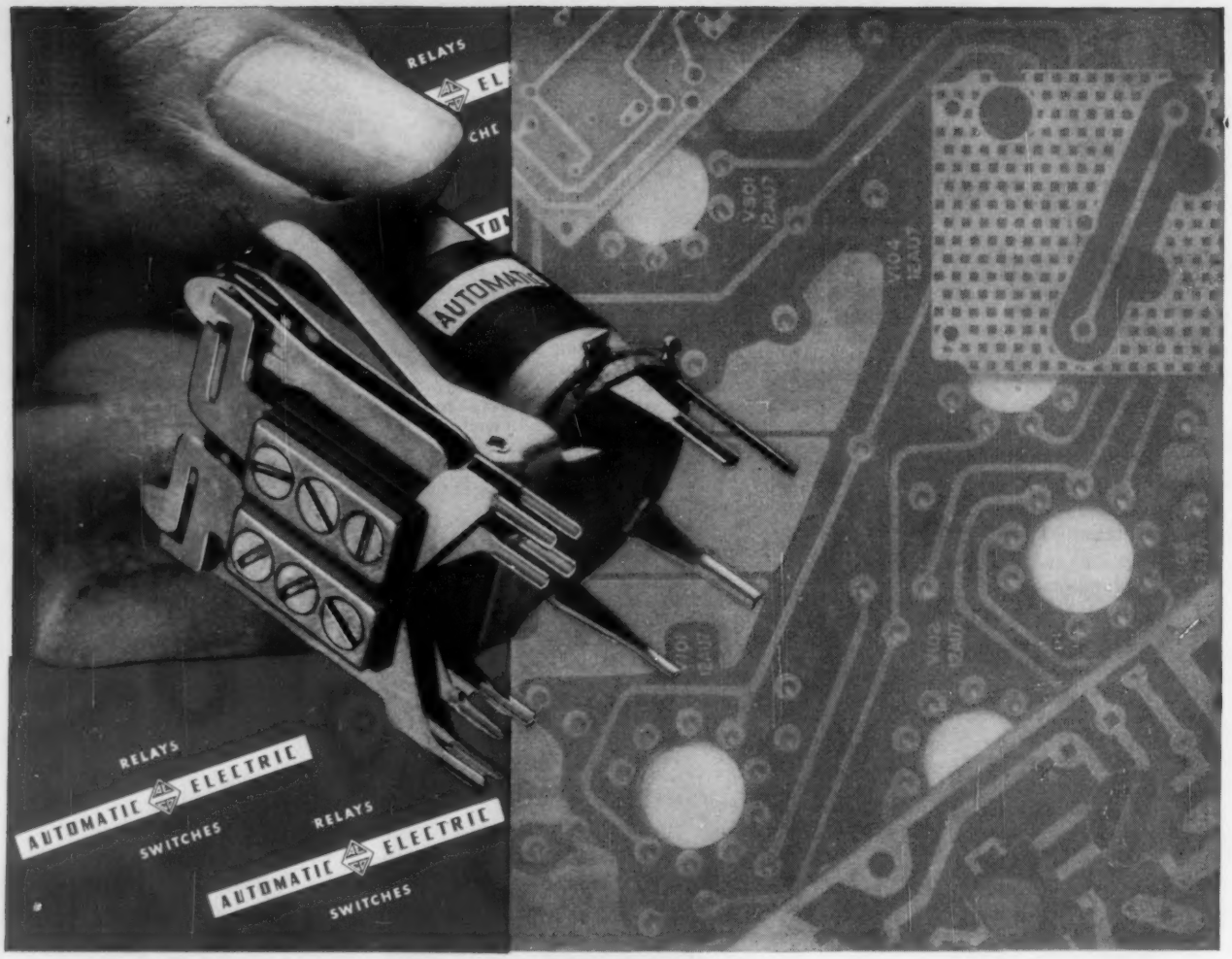
5615

Automatic Punched-card Sorter

New "Electronic Sorter" sorts 48,000 alphabetic, numeric, blank and special code punched-cards per hour. Push-button simplicity assures instant selection of column to be sensed; and variable sequence, sorting 0-to-9, A-to-M, and N-to-Z cards in any order. A complete alphabetic sort or a complete alpha-numeric sort is provided through 13 receivers for cards selected automatically, plus a 14th receiver for non-selected cards. Double capacity feeding magazines and card receivers permit efficient extra output for unit.—*Remington Rand Div., Sperry Rand Corp., 315 Fourth Ave., New York 10, N. Y.*

For more information circle **226** on inquiry card.

5777



NOW!

dependable relays for printed circuits

Maybe you, too, have been awaiting availability of a *good* relay for direct insertion into printed circuits. Now Automatic Electric can solve your problem with a miniature relay that is just right.

120 million operations, without a single readjustment or relubrication! That's what you get from this rugged, improved Series SQD Relay, because it features a special *heavy-duty* bearing and bearing pin. Also a recess in the bearing plate retains an adequate supply of lubricant for long-term lubrication of the bearing pin.

Consider these additional advantages:

1. The sections of the terminals that insert into the printed circuit board are NOT brazed or welded into place, but are integral parts of the coil terminals and contact springs—thus preventing internal loss in conductivity or continuity.
2. Terminal design permits direct plug-in of the relay into a printed circuit board, ready to be secured in place with any acceptable soldering technique.

Usually the desired contact spring combination, or pile-up, is sufficiently large so that additional mounting (support) of the relay is not necessary.

SQD Miniature Printed Circuit Relays are available with many different contact spring arrangements, and for a multitude of applications. Springs can be made of phosphor-bronze, "Bronco" metal, or other special-purpose materials, as required.

Of course the long life, heavy-duty features of the improved SQD Relay can be had in the conventional type of plug-in relay, if regular sockets are preferred for use, whether in printed circuitry or other applications.

To get complete details, write: Automatic Electric Sales Corporation, 1033 West Van Buren St., Chicago 7, Illinois. *In Canada:* Automatic Electric (Canada) Ltd., Toronto. *Offices in principal cities.*

RELAYS SWITCHES

PRODUCTS OF THE INDUSTRIAL DEPARTMENT OF

AUTOMATIC ELECTRIC

CHICAGO

For more information circle **67** on inquiry card.

Absolute Pressure Pneumatic Transmitter

New "Metagraphic" transmitter measures pressures in ranges as low as 0-5 mm and as high as 0-760 mm mercury absolute; transmits standard 3-15-psi pneumatic signal; can therefore be used with any standard pneumatic receiver or automatic controller.—*The Bristol Company, Waterbury* 20, *Conn.*

For more information circle **227** on inquiry card.

McLeod Gage

New improved model of "Lippincott" McLeod gage zeros automatically and incorporates alignment stop bracket. Automatic zero is a mercury overflow device which regulates height of reference or control capillary leg to zero point on scale: excess mercury is caught in a built-in trap. Alignment stop bracket arms prevent rotation of glass portion of gage beyond reading and evacuating positions. Four available ranges: 0-1, 0-5, 0-10 and 0-15 mm. Gage can be used as a bench instrument, mounted on a framework or inserted in an all-glass system.—*Kontes Glass Co., Vineland, N. J.*

For more information circle **228** on inquiry card.

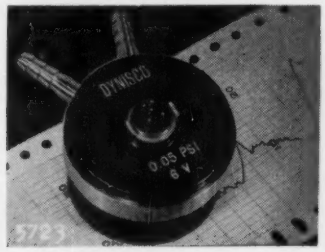
Pressure Switch

New pressure switch, available in single- and double-terminal models, in ranges to 100 psi; is encased in a stamped-steel hermetically-sealed case; features close on and off settings. Spring-loaded diaphragm can be equipped with optional additional overload protection. Dimensions: 1¾" wide and 2-1/16" from top of terminal to end of fitting. Available with ¼" or ⅛" threaded fitting.—*Rochester Mfg. Co., Inc.,* 100 *Rockwood St., Rochester* 10, *N. Y.*

For more information circle **229** on inquiry card.

Low-pressure Pickup

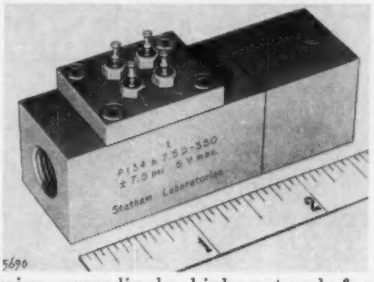
New "Dynisco," smaller and lighter than many existing types of low-pressure pickups, measures either gage or differential pressure in ranges 0.00-0.05 and 0.00 to 1.00 psi. A 1⅞" diam beryllium-copper bellows actuates a strain-sensitive resistance bridge. Acceleration sensitivity is held to 0.001 psi/G and effect of lateral accelerations is negligible. Unique unbonded strain-gage bridge assembly weighs 0.14 oz, is available for ac or dc excitation voltages of 6, 12, or 15 v, for bridge resistances of 350, 600, or 800 ohms, and minimum full-scale outputs of 20, 40, or 50 mv, respectively. Resolution is 0.02% of full-scale and measurements are accurate to 0.5% at 70°F.—*Dynamic Instrument Co., Inc., 28 Carleton St., Cambridge, Mass.*



For more information circle **230** on inquiry card.

Differential-pressure Pickup

New "Model P 134" features use of maker's unbonded-wire deflectometer method; line pressure rating of 250 psig; exceedingly high natural frequency and relative insensitivity to acceleration; temperature compensation; ranges from ± 2.5 to ±25 psid and 0-5 to 0-150 psid.—*Statham Labs., 12401 W. Olympic Blvd., Los Angeles 64, Calif.*



For more information circle **231** on inquiry card.

High-vacuum Gage Tube

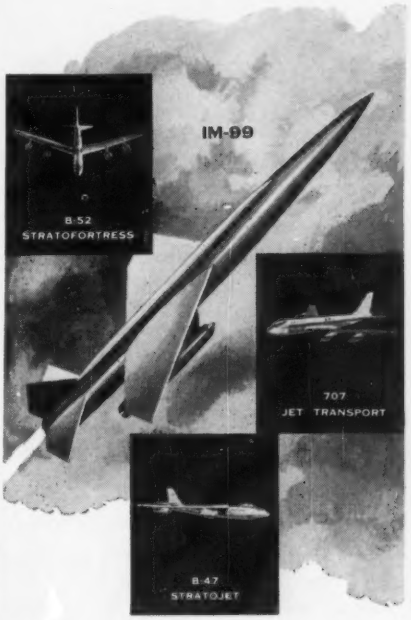
New "Type RG-75" is said to be "the first hot-wire ionization gage that can be operated at atmospheric pressure without burning out and with no permanent effect on subsequent readings." In addition, it is suitable not only for high-vacuum but for ultrahigh-vacuum work. Range has been extended to below 10^{-10} mm Hg, and outgassing minimized, by employing Bayard-Alpert inverted structure: fine-wire collector inside helical grid, filament outside grid. "RG-75" tube is conveniently operated with maker's linear "Type RG" circuits.—*Vacuum Electronic Engineering Co., 86-J Denton Ave., New Hyde Park, N. Y.*

For more information circle **232** on inquiry card.

Do you think about Angular Acceleration?

BOEING does

...and uses Statham Angular Accelerometers to test...



Statham unbonded strain gage liquid rotor angular accelerometers offer a simple, reliable means for the study of the rotary motion of a test body under conditions where a fixed mechanical reference is not available. For static and dynamic measurements in ranges from ±1.5 to ±3,000 rad/sec², four standard models are offered.

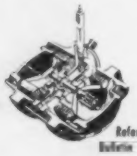
Please request Bulletin AA2

Statham
LABORATORIES
LOS ANGELES 64, CALIFORNIA

For more information circle **68** on inquiry card.

BARTON RUPTURE PROOF SWITCH for flow, liquid level or differential pressure, with separably adjustable mercury-in-glass contacts to actuate alarms, control pumps or other electrical apparatus. Available with high, low, high and low, double high or double low contacts, operating from 0-20" W.C. to 0-400" W.C., at S.W.P. to 4500 psi., where high accuracy, rugged construction, simple operation, continuous dependability, inexpensive installation and low maintenance are required.

For further information request Bulletin 211-1 or contact BARTON sales engineers in most principal cities.



MODEL 199 METER BODY

MODEL 200 INDICATOR

MODEL 202 RECORDER

MODEL 214 TRANSMITTER

BARTON INSTRUMENT CORPORATION
INDUSTRIAL INSTRUMENTS
1429 SOUTH EASTERN AVENUE · LOS ANGELES 22, CALIFORNIA
For more information circle **69** on inquiry card.

INSTRUMENT ENGINEERS

Pittsburgh Consolidation Coal Company is now entering the process industries. This calls for further expansion of our Research and Development activity in the general field of coal conversion and includes the need for additional instrument engineers in development and technical service work.

We welcome replies from BS-MS instrument engineers who majored in Chemical or Mechanical Engineering or Chemistry and with 0-8 years experience.

These positions offer technical challenge and the opportunity to participate in the growth and expansion of this large company into the process industries. Completed research and development projects now being commercialized include long distance coal pipeline and multi-million dollar chemical plant in Newark, New Jersey. Other projects include continuous carbonization, complete refining of tar oils, gas synthesis, etc.

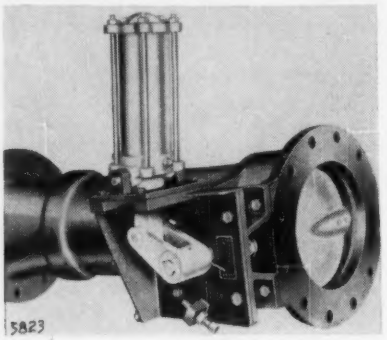
Please address replies, including education, experience, references and salary desired to:

William F. Saalbach
Adviser on Personnel
Research & Development Division
Pittsburgh Consolidation Coal Company
Library, Pa. (13 miles south of downtown Pittsburgh)

FLOW-RATE

Flow-rate Controller

New "Model RCB-T" power-actuated flow-rate controller comprises a Venturi metering section and a pressure recovery section, a power-actuated valve mechanism, and a pneumatic, hydraulic, or electric positioning control unit. Bronze-lined Venturi



throat section is dimensioned and contoured for maximum accuracy and for preventing corrosion and tuberculation. Among features: low head loss; accuracy within 3% ranging from 25 to 100% of maximum capacity.—*Builders-Providence, Inc., 345 Harris Ave., Providence, R. I.*

For more information circle **233** on inquiry card.

Flow-rate Pickup

New ⅛" "Flow Sensor" is for measurement of extremely low flows with 0.5% accuracy on an instantaneous basis. Range 0.07 to 0.7 gpm. Unit produces an a-c output signal whose frequency is directly proportional to flow; can be used either with a digital counting or computing system or with an electronic frequency converter which operates a flow-rate indicating, recording or controlling system. On a digital basis, each output pulse produced by pickup represents a quantity of 0.00003 gal. Units are available for operation at temperatures from −300°F to 450°F; higher-temperature units on request.—*Potter Aeronautical Co., Route # 22, Union, N. J.*

For more information circle **234** on inquiry card.

Flow-rate Indicator

New "F-8110 Direct Reading Flow Rate Meter," for circulating, lubricating and fueling systems, weighs 1½ lb; has one moving part; covers flow

range of 7 to 70 gph; operates at temperatures of −65° to 160°F; is accurate to 2% of specified flow rate and has a low pressure drop.—*Kevere Corp. of America, Wallingford, Conn.*

For more information circle **235** on inquiry card.

LIQUID and granular material LEVEL

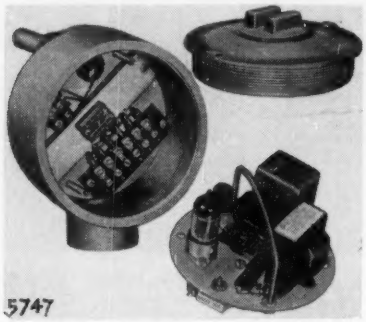
Float Switch

New "F-8685 Float Level Indicator" weighs 0.9 oz; is 3.31" long, has no exposed metal parts; can be used with solvents, oils, acids, etc. Sp-st switch (rated 10 watt at 115 vac, 0.5 amp res or ind load at 28 vdc) has 100,000-cycle minimum life, is enclosed in a nylon stem and is actuated by permanent magnets imbedded in free float.—*Revere Corp. of America, Wallingford, Conn.*

For more information circle **236** on inquiry card.

Capacitance Level Alarm

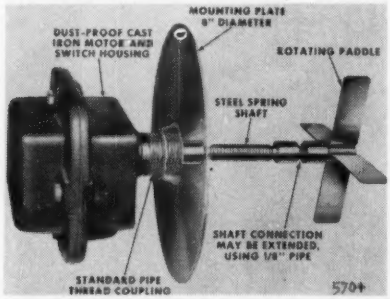
New "Model B-06 Electr-O-Probe" capacitance-operated level alarm features unitized construction; easily-removed plug-in chassis assembly; explosion-proof housing suitable for use in hazardous areas (Class 1, Group D); compact design obviating need for connecting cable between probe and relay unit.—*Instruments, Inc., 122 N. Madison, Tulsa 6, Okla.*



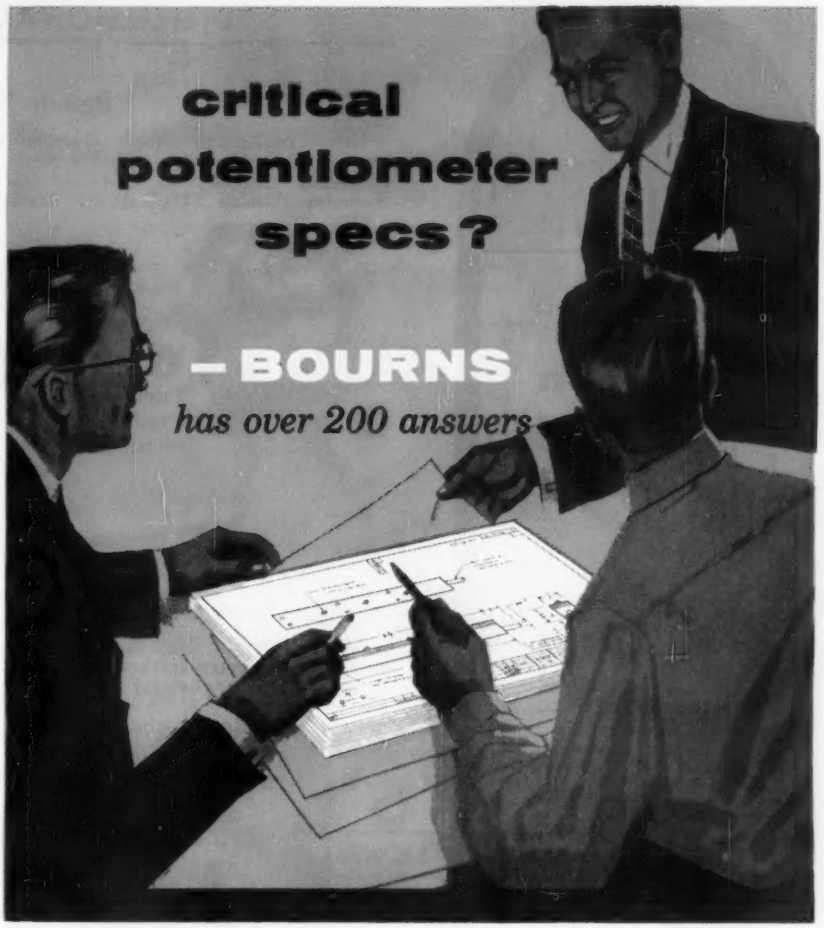
For more information circle **237** on inquiry card.

Bin Level Indicator

New "Roto-Bin-Dicator" is particularly adaptable to installations in bins under pressure or vacuum; bins, chutes or conveyors handling materials containing large lumps which tend to "bridge" over a diaphragm; and bins handling materials which tend to "rat-hole" and prevent operation of a diaphragm.—*The Bin-Dicator Co., 13946-201 Kercheval Ave., Detroit 15, Mich.*

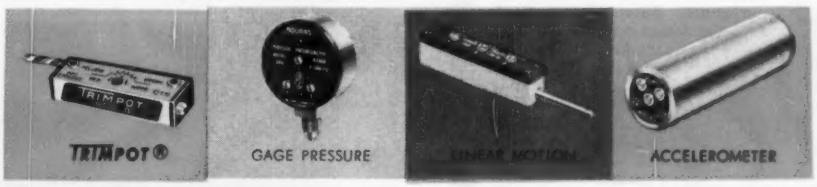

MOUNTING PLATE 8" DIAMETER
DUST-PROOF CAST IRON MOTOR AND SWITCH HOUSING
ROTATING PADDLE
STEEL SPRING SHAFT
SHAFT CONNECTION MAY BE EXTENDED, USING 1/8" PIPE
STANDARD PIPE THREAD COUPLING
5704

For more information circle **238** on inquiry card.



To fit numerous applications, Bourns has 200 designs of miniaturized, high-performance sensing instruments on file. These designs are either standard types, or variations made to meet critical electrical and environmental specifications. The pressure potentiometer designs range from ½ to 10,000 p. s. i. Linear motion units provide travels of ⅛" to 30", and you can choose from a wide variety of resistance ranges.

The instrument you need may be among these Bourns designs – ready for production from parts in stock. Or one of the designs now on our boards may meet your specs. If not, we will gladly consider developing the instrument you require. Send us your specifications – your problem may already be solved.



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6135 Magnolia Avenue, Riverside, California

Technical Bulletins on Request, Dept. 22

For more information circle **70** on inquiry card.

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0.001 volt input d-c gives 70 mm. deflection with this high-speed direct writing oscillograph, many times that for competitive units. The Dynograph with *one amplifier* is used for all types of inputs for measuring speed, temperature, position, vibration, and other variables. Patented, chopper amplifier design makes it sensitive, stable, and versatile. Available in both 6 channel console model and single and dual channel portable models. *Get bulletin L742—compare the Dynograph with all competitive models—it combines sensitivity with absolute stability.*

OFFNER ELECTRONICS INC.
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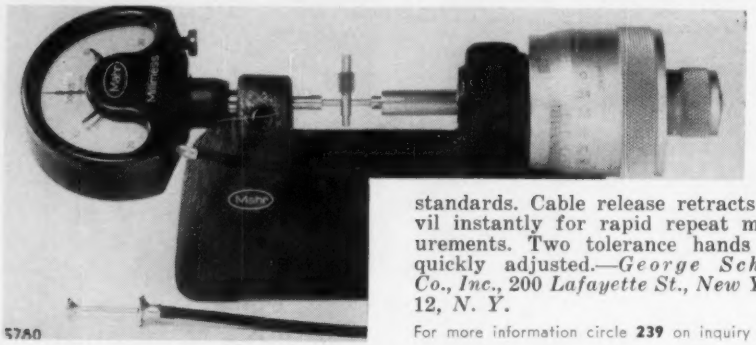
For more information circle **71** on inquiry card.

DIMENSIONAL GAGING, etc.

Bench Micrometer

New "Indicating Bench Micrometer" with non-rotating spindle reads to 0.0001" directly on over-size micrometer thimble (1¾" diam). Indicating head is graduated in 0.00005" with plus and minus 0.002" range (total range 0.004"). As a comparator, it can be set without additional

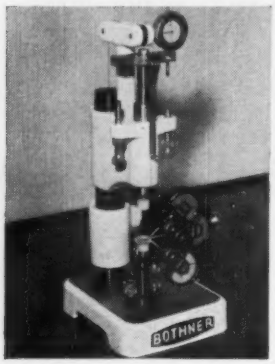


standards. Cable release retracts anvil instantly for rapid repeat measurements. Two tolerance hands are quickly adjusted.—*George Scherr Co., Inc., 200 Lafayette St., New York 12, N. Y.*

For more information circle **239** on inquiry card.

Lens Tester

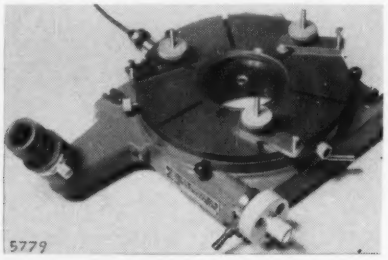
New automatic lens tester checks thickness, diameter and eccentricity of lenses or other spherical bodies; utilizes automatic self-centering principle; can be used individually or in conjunction with Bothner lens centering machine.—*Alfa Photo Corp., 303 W. 42nd St., N. Y. 36, N. Y.*



For more information circle **240** on inquiry card.

Optical Rotary Stage

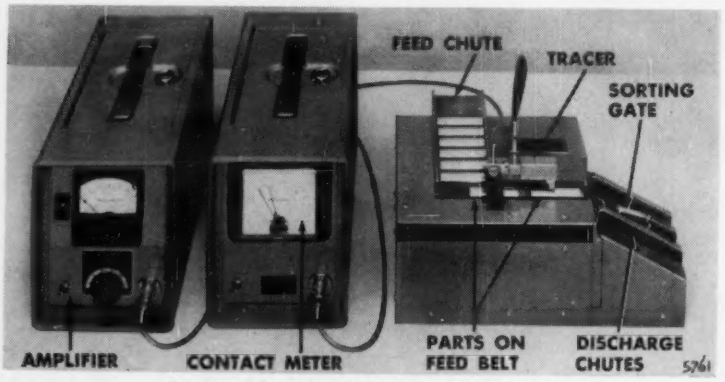
New "Precision Optical Rotary Table" is suitable for use in small precision machine tools and co-ordinate measuring instruments, also for difficult inspection setups. Working accuracy is obtained optically and will therefore be maintained indefinitely. Master is a 360° glass circle; vernier scale reads to 1 min of arc, with possibility of estimating 30 sec which is guaranteed accuracy.—*George Scherr Optical Tools, Inc., 200 Lafayette St., New York 12, N. Y.*



For more information circle **241** on inquiry card.

Surface-roughness Automation Inspector

New equipment permits addition of surface-roughness inspection to automated production setups; sorts parts in accordance with microinch roughness measured along an OD or flat surface, including tapers and parts with grooves or shoulders. Each application is engineered to user's requirements.—*Micrometrical Mfg. Co., 345 S. Main St., Ann Arbor, Mich.*



For more infromation circle **242** on inquiry card.

COUNTING

Electronic Counters

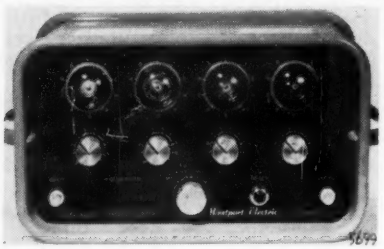
New "Detectron DS-700 Series Batch Counters" are especially designed for such applications as: indus-

trial batch counting; testing engines, turbines and motors; counting total revolutions of high-speed shafts; etc.; will count at speeds up to 100,000/sec. Mechanical register extends maximum count capacity (to 9,999,999,999 on 4-decade unit).—*The Computer-Measurements Corp., 5457 Cleon Ave., North Hollywood, Calif.*

For more information circle **243** on inquiry card.

Preset Counter

New "Model WE-310" is said to feature "basic simplicity and long term dependability." Operator can set

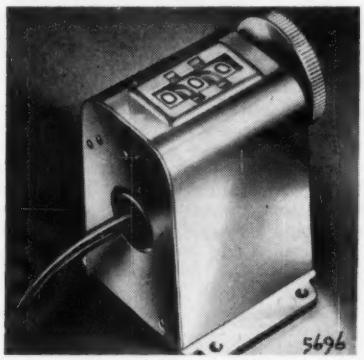


in any number from 1 to 9,999; instrument will count until this total has occurred; then, coincident with last input pulse, provide an output pulse. Response speed to 5000 pulses per second (100 usec minimum pulse duration).—*Westport Electric, 149 Lomita St., El Segundo, Calif.*

For more information circle **244** on inquiry card.

Reset Magnetic Counter

New "Series 1507" is for moderate counting duty where extreme long life is not required. Maximum recommend-



ed speed 700 counts per minute. Dimensions about 2¼" wide by 2½" high. Standard counter has 3 figures (4 on special order). Panel mounting available as special.—*Veeder-Root Inc., Hartford 2, Conn.*

For more information circle **245** on inquiry card.

Kearfott Servo Motor-Generators are characterized by low rotor inertia, low time constants and high stall torque. Motor-Generator combinations provide ½ to 3.1 volts per 1000 R.P.M. with an extremely linear output over a speed range of 0—3600 R.P.M. and useful output up to 10,000 R.P.M.

CHARACTERISTICS				
TYPE	MOTOR		GENERATOR	
DAMPING	STALL TORQUE	NO LOAD SPEED	OUTPUT FUND. NULL	LINEARITY
SIZE 10	.35 OZ. IN.	6000	21/1	.5%
SIZE 10	.30 OZ. IN.	8500	23/1	.5%
SIZE 11	.63 OZ. IN.	5900	25/1	.5%
SIZE 15	1.5 OZ. IN.	5000	25/1	.5%
SIZE 18	2.4 OZ. IN.	5000	25/1	.5%
SIZE 18	3.0 OZ. IN.	9600	23/1	.5%
RATE				
SIZE 15	.45 OZ. IN.	10,500	170/1	.5%
SIZE 15	1.5 OZ. IN.	4700	350/1	.2%
SIZE 18	2.4 OZ. IN.	4700	350/1	.2%
SIZE 18	3.0 OZ. IN.	8400	350/1	.2%
*INTEGRATOR				
SIZE 15	.70 OZ. IN.	6300	400/1	.1%
SIZE 15	1.25 OZ. IN.	4500	400/1	.1%
SIZE 18	1.35 OZ. IN.	7200	400/1	.1%
SIZE 18	2.4 OZ. IN.	5200	333/1	.05%
SIZE 18	3.0 OZ. IN.	8000	333/1	.05%

*Integrator Tachometers are temperature stabilized

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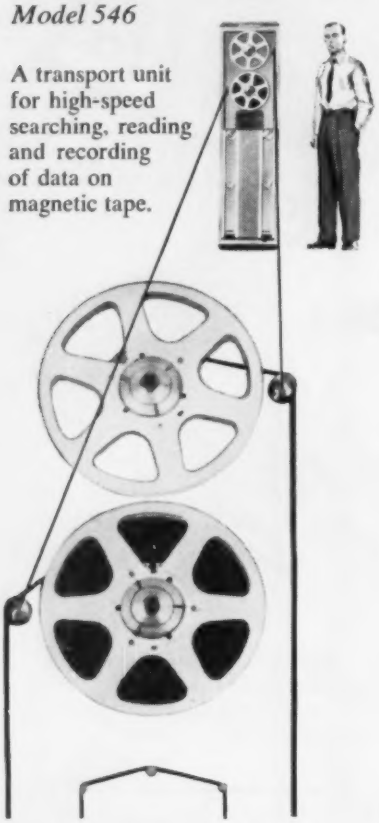
For more information circle **72** on inquiry card.

DataReader

Model 546

A transport unit for high-speed searching, reading and recording of data on magnetic tape.



End-of-tape sensing

Slotted, hollow guide shafts, one adjacent to each tape reel are constantly subjected to a vacuum which is maintained as long as normal tape is passing over, and sealing the shaft openings. Perforated leaders at either end of the tape interrupt the vacuum and stop the tape reels. This feature also provides an automatic stop in the event of tape failure.

PERFORMANCE:

RAPID START—STOP—REVERSE—from stop to full speed in 6 milliseconds.

HIGH TAPE SPEED—optional single speed of 30, 40, 50, 60 or 75 in/sec.

TWO-DIRECTION SEARCH—either direction, automatically at full speed.

REMOTE OPERATION—forward, reverse, stop, rewind and selection of reading and writing.

VACUUM COLUMN TAPE CONTROL—provides strain-free tape feed over entire length of tape.

RAPID REWIND—2400 ft. of ½" or ¾" tape in 3 minutes.

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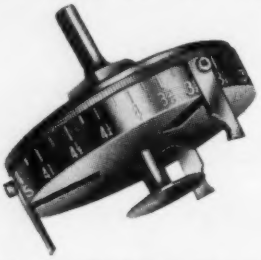
For more information circle **73** on inquiry card.

SHOP EQUIPMENT

Hole Cutter

New hole cutter that will cut holes in steel, brass, plastic, wood, etc.,

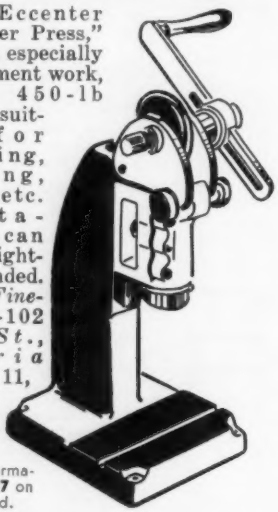


from 2¼" to 5" diam.—*Erwood Inc. 1770 W. Berteau Ave., Chicago, Ill.*

For more information circle **246** on inquiry card.

Hand-lever Press

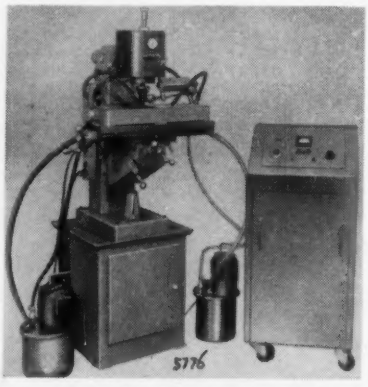
New "Eccenter Hand Lever Press," designed especially for instrument work, develops 450-lb force; is suitable for broaching, punching, swaging, etc. Adjustable lever can be used right- or left-handed. —*A. R. Fineisen*, 114-102 *230th St., Cambria Heights* 11, *N. Y.*



For more information circle **247** on inquiry card.

Ultrasonic Machine-tool

New models of maker's ultrasonic machine tools are called "Raytheon Impact Grinder," new name being



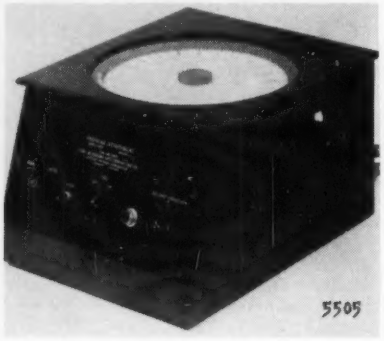
more descriptive of actual cutting action. New models incorporate a number of design changes together with improvements in pedestal mounting and cutting head. "Model 2-332-1" employs a single abrasive circulating unit; "Model 2-332-2" has a dual abrasive unit making two different grit sizes immediately available without risk of intermixing.—*Raytheon Mfg. Co., Waltham* 54, *Mass.*

For more information circle **248** on inquiry card.

LABORATORY

Automatic Spectrophotometer Program Control

New automatic spectrophotometer program control permits repetition of a spectral scan at predetermined in-



tervals over a 24-hour period without attention from an operator; can be used with maker's spectrophotometers to follow the course of reactions, in reaction rate studies, in continuous analysis of flowing samples, in analysis of chromatographic effluents, etc. Instruments can be used on routine work during day and set up with program control for automatic operation during night.—*Applied Physics Corp., 362 W. Colorado St., Pasadena* 1, *Calif.*

For more information circle **249** on inquiry card.

Liquid Scintillation Spectrometer

New "Tri-Carb Spectrometer" provides a simple, convenient method for precise counting of beta samples in

solution with liquid phosphors; will efficiently count isotopes with such low beta energies as tritium and carbon-14, either individually or in mixtures; is equally adaptable to others such as sulphur-35 and calcium-45. Counting is rapid and large numbers of samples can be handled.—*Packard Instument Co., Dept. I&A, P. O. Box 428, La Grange, Ill.*

For more information circle **250** on inquiry card.

X-ray Counter Tube

New "Norelco No. 62030" Geiger-counter tube is designed for X-ray spectrographic work involving elements such as phosphorus, silicon and aluminum. Resolving time about 150 usec; threshold about 800 v; slope of

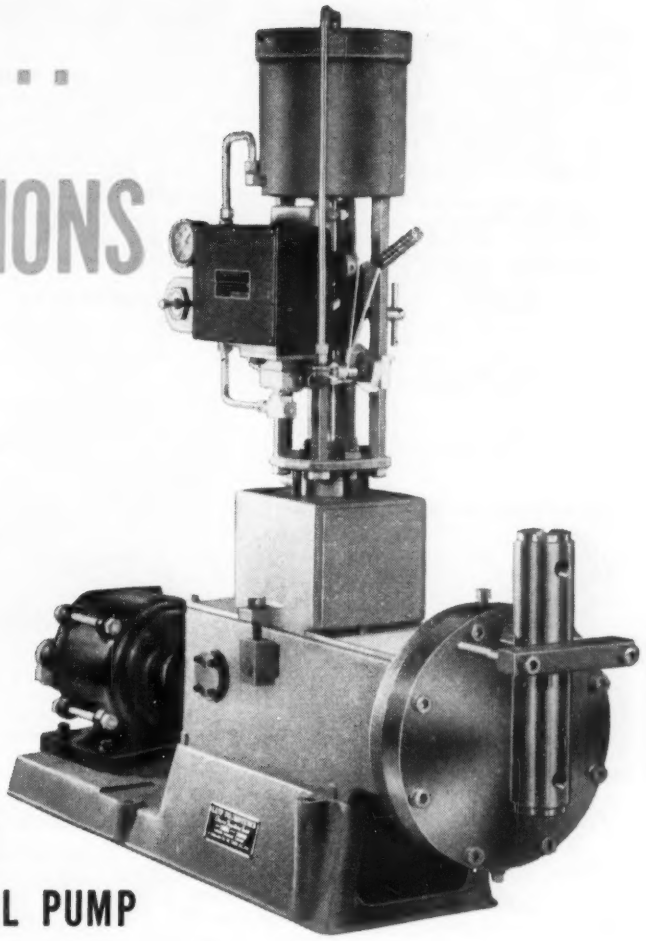
IT PUMPS...

IT METERS...

IT PROPORTIONS

IT FEEDS...

WITHOUT LEAKAGE OR CONTAMINATION



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If your process requirements demand accurate handling of corrosive and non-corrosive liquids, here is the pump for the job. The Lapp Pulsafeeder is a piston-diaphragm pump . . . it has positive displacement with *no stuffing box.* The product being pumped is isolated from the drive mechanism by a hydraulically balanced diaphragm, thus preventing leakage or contamination of the product. Pumping speed is constant; variable flow results from variation in piston-stroke length . . . controlled manually by hand-wheel, or, in Auto-Pneumatic models, by instrument air pressure responding to any instrument-measurable processing variable.

WRITE FOR BULLETIN 440 *with typical applications, flow charts, description and specification of models of various capacities and constructions. Inquiry Data Sheet included from which we can make specific engineering recommendation for your processing requirement. Write Lapp Insulator Co., Inc., Process Equipment Division, 512 Wilson Street, Le Roy, N. Y.*

Lapp

For more information circle **74** on inquiry card.

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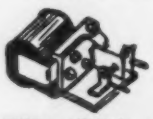
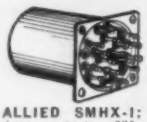
D167584; (Equivalent to 275B); SPDT; 1 coil of 4500 ohms plus 24V Heater; High pressure sealed; Octal plug base. Operating current: 6.6 ma, release current: 5.2 ma. Overall length: 3¼", overall diameter: 1-3/16"; #R1021 .....6.95 ea
10 for 65.00 100 for 625.00
D168479; (Equivalent to 275C); SPDT; 2 coils: 3300 and 700 ohms; High pressure sealed; Octal plug base. Operating current: Windings in series 6.6 ma, release: 5.2; #R1022 .....8.95 ea
10 for 82.50 100 for 750.00

SIGMA SENSITIVE RELAYS



SIGMA 4F8000S; 1 ma; SPDT(1C); 8000 ohm; #R425 .....3.95 ea
3 for 10.00 10 for 30.00
SIGMA 5F16000S; 0.5 ma; SPDT(1C); 16000 ohm; #R627 .....5.95 ea
10 for 50.00 100 for 450.00
SIGMA 5J016000LG; 1 ma; 1C, 1A; Octal plug base; Hermetically sealed; #R1118 .....3.95 ea

HERMETICALLY SEALED RELAYS



ALLIED SMHX-I; 24VDC; 6PDT(6C); 10 Amp contacts; 230 ohm; Solder lug header; #R271 .....6.50 ea
ALLIED SKHXCC; 24VDC; DPDT(2C); 425 ohm; Solder lug header; #R85 .....5.95 ea
ALLIED SKHXCCCC; 24VDC; 4PDT (4C); 425 ohm; Solder lug header; #R86 ....5.95 ea
POTTER BRUMFIELD MH-17AM; 115V, 50-60 cyc; 4PDT; Solder lug header; #R87 .....6.95 ea

A-C RELAYS

GUARDIAN SNAP-ACTION; SPST; 30 Amp contacts; 115V, 50-60 cyc; #R1023 ...1.95 ea
10 for 18.00
220V, 50-60 cyc; #R1024 .....2.50 ea
10 for 22.50

ALLIED PO12AII5; 115V, 50-60 cyc; 4PDT; 10 Amp contacts; #R1025 ..4.50 ea
10 for 40.00 100 for 350.00

24 VOLT TRANSFORMER: 1.5 Amp; Pri: 115V, 50-60 cyc; Double shielded; Net wt: 1½ lb; #T120 .....1.50 ea
10 for 13.00 100 for 100.00

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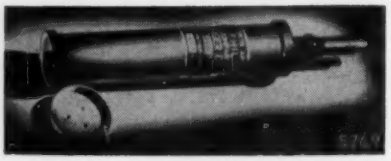
For more information circle **75** on inquiry card.

NEW INSTRUMENTS

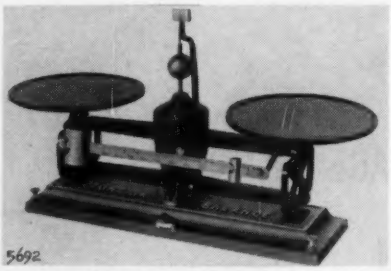


plateau 10% maximum, and end of plateau over 1100 volts. Slope depends on counting rate and electronic measuring circuits. (10% figure is based on a rate of 100/sec at a sensitivity of 1 volt). Operating potential 900 v. Tube is filled with neon and is halogen quenched.—*No. Am. Philips Co., Inc., 750 So. Gulton Ave., Mt. Vernon, N. Y.*

For more information circle **251** on inquiry card.

Laboratory Balance

New "Model HT-1" is said to combine large capacity with high sensitivity: it has an S.R. of 0.75g and a

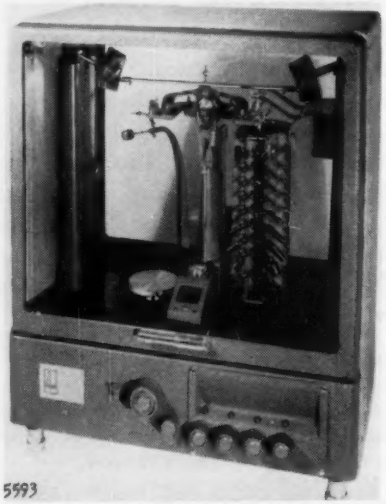


capacity of 14 kg. Two slide weights on single beam permit weighings from 1 to 1000 g without use of loose weights.—*The Torsion Balance Co., Clifton, N. J.*

For more information circle **252** on inquiry card.

Analytical Balance

New "Unigram" semi-automatic projection balance reads directly to 200 g in steps of 0.1 mg; weighs in



seconds; requires no external weights; is said to give unequalled reproducibility. Optical projection system automatically displays weights in range of 0.0000 to 0.1000 g. Weights from 0.1 to 100 g are controlled by knobs and are read directly from dials.—*Voland and Sons, Inc., New Rochelle, N. Y.*

For more information circle **253** on inquiry card.

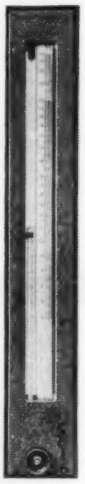
pH Meter

New "Model 110 Line-Operated pH Meter" covers entire pH range from 0 to 14 without switching and without

reversal of pointer travel; is intended mainly as a lab type instrument but can be furnished in portable style with baseboard and carrying cover; is perfectly stabilized; operates on any line from 90 to 270 vac. Accuracy 0.02 pH. —*Photovolt Corp., 95 Madison Ave., New York 16, N. Y.*

For more information circle **254** on inquiry card.

Viscometer



New "Type II Viscometer," said to be the first of its kind ever developed "for directly determining in a matter of minutes the kinematic viscosity of fuels, light oils, and non-corrosive liquids," is suitable for lab or field use. It utilizes an advanced flow system design, enabling readability within 1% of indicated viscosity at any point of scale. Ranges 0.5 to 5 and 3 to 30 centistokes (covering all liquids used in testing aircraft fuel and hydraulic system components). Supplied as a portable unit or as a panel-mounted unit. Weight 8 lbs, includes thermometer, filter, filter cartridge, and AN outlet fittings.—*Commercial Research Labs, Inc., 20 Bartlett Ave, Detroit 3, Mich.*

For more information circle **255** on inquiry card.

Cone-and-plate Viscometer

New "Ferranti-Shirley Viscometer" embodies cone-and-plate principle in an arrangement of advanced design,

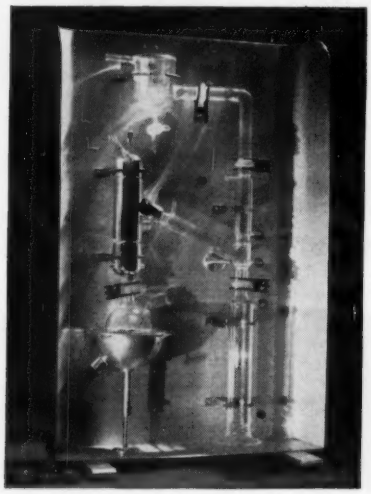
which enables flow properties of most types of simple or complex fluids to be measured simply and rapidly. Thin sample film involved (average 0.004

in thick) reaches temperature stability almost instantly. Three cones of different diameters, with two speed ranges and five torque measuring ranges, allow rates of shear from 18 to 18000/sec with shear stress in samples from 0 to 560,000 dynes/cm². For Newtonian materials, scale can be calibrated in poises.—*Ferranti Electric, Inc., 30 Rockefeller Plaza, New York 20, N. Y.*

For more information circle **256** on inquiry card.

Vacuum Column

New unitized ASTM-type vacuum-distillation column has facilities for rapid access to all parts requiring



removal or adjustment during operation.—*Glass Engineering Labs., 555 O'Neill Ave., Belmont, Calif.*

For more information circle **257** on inquiry card.

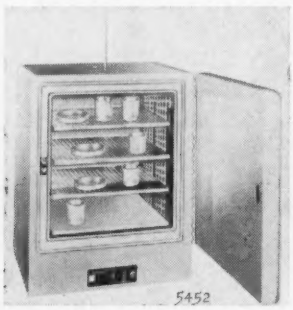
Water Still

Newly redesigned "Midget" portable laboratory water still for small-volume users of distilled water is smaller than a 5-gal carboy; weighs 10 lbs.; produces ½ gal of pyrogen-free distilled water per hour; is made of stainless steel and copper, with all critical surfaces coated with block tin to safeguard distilled-water purity.—*Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.*

For more information circle **258** on inquiry card.

Laboratory Ovens

Three new forced-draft "Thermo-Circulator" ovens fill gap between maker's "Radiant Wall" ovens and

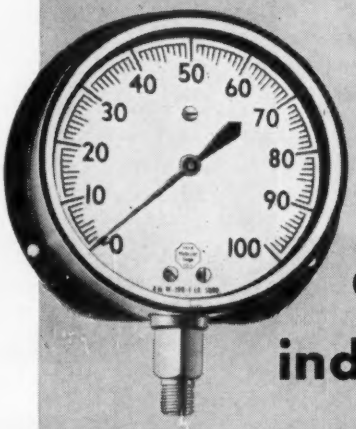


"Force-Aire Bench-Saver" ovens. Two temperature ranges, 200° C and 260° C; two sizes, 11 x 13 x 13 in and 16 x 20 x 18 in; aluminum or steel interiors. No internal heaters: walls are heated by external clamped-on heat-

an ACCO product

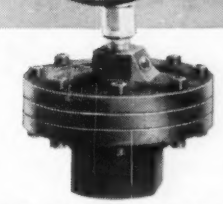
Helicoid Gages

Why HELICOID is the Quality Gage for every pressure indicating service



Acaloy Case Helicoid Gage

Suitable for tap water, steam, inert gases, oils, coal gas and many chemicals.



Helicoid Chemical Gage

Suitable for chemicals and other viscous liquids which might corrode or clog Bourdon tube.

Built RIGHT

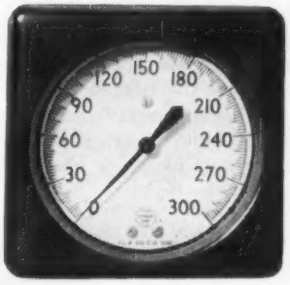
Exclusive HELICOID gearless movement. Bourdon tubes of maximum endurance life. Gives highest degree of *sustained accuracy.*

Stay RIGHT

No gear teeth to wear out. Convenient external pointer adjustment. Protected from sudden overpressure or pressure reduction.

Sold RIGHT

Experienced HELICOID gage engineers are available to help you choose the gage you need. Distributors are conveniently located. Write for the name of the one nearest you.



Acaloy Square Flush Case

This is a weather-proof case and ideal for use in symmetrical panels.

ACCO

TRADE MARK

Helicoid Gage Division

AMERICAN CHAIN & CABLE

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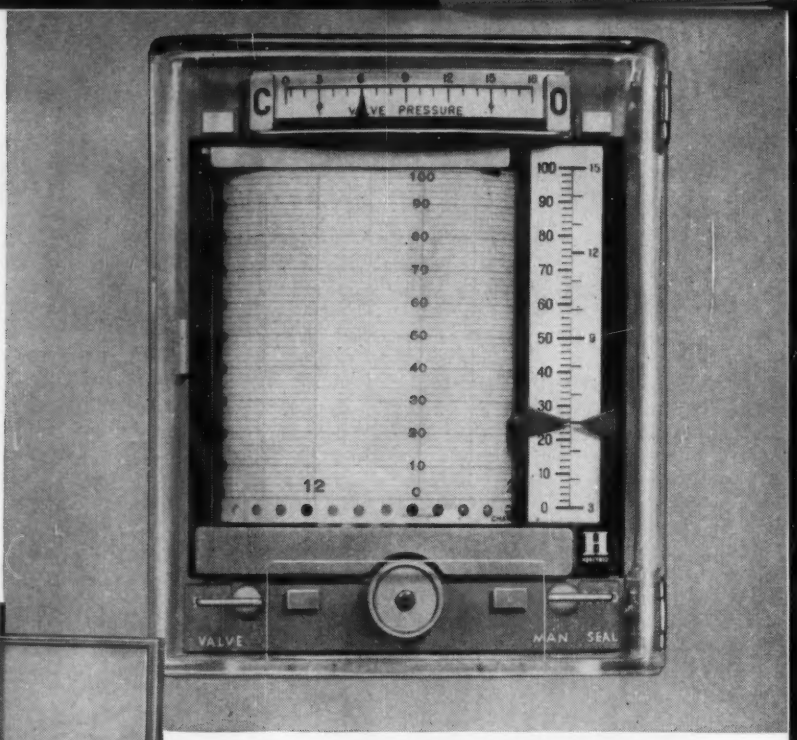
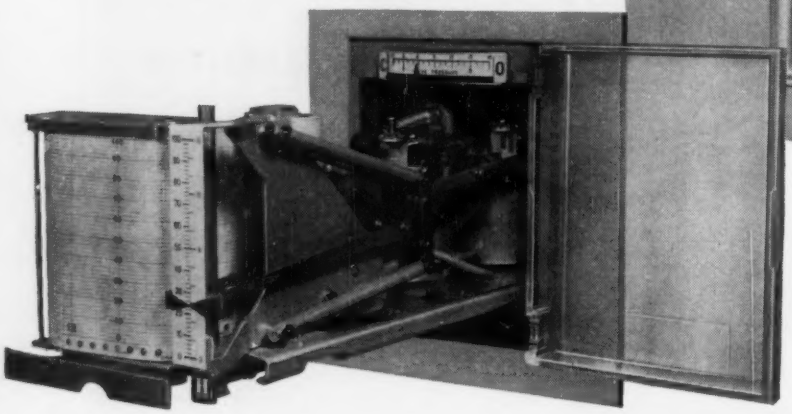
for Better Value

For more information circle **76** on inquiry card.

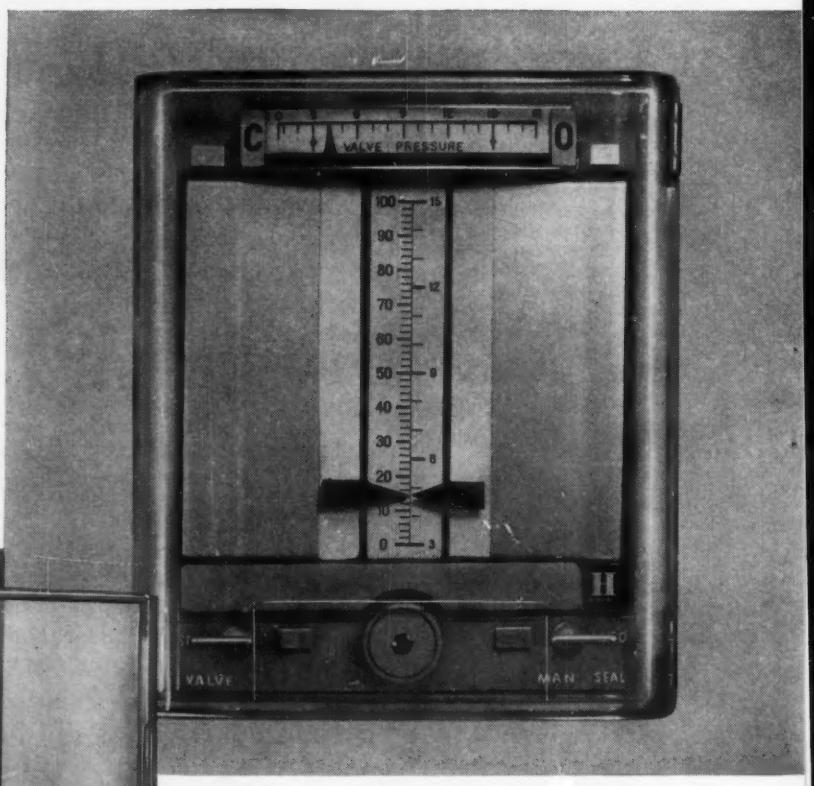


TEL-O-SET RECORDER

takes panel cut-out only 5-1/32" high by 4-9/16" wide. Chassis slides out of case as a complete unit . . . can be shipped separately to prevent damage and collection of dirt or dust awaiting start-up. In partially withdrawn position, the internal mechanism is accessible for adjustments. Uses identical case as indicator. Bottom-of-case location of control knobs permits instrument to be mounted higher on the panel.

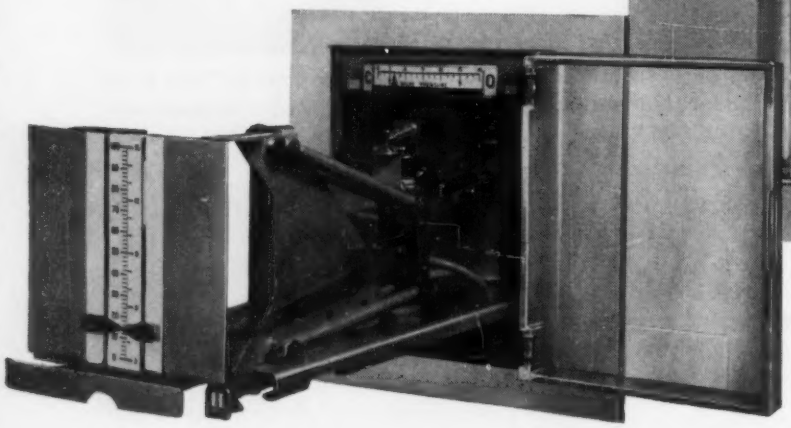


today's



NEW TEL-O-SET INDICATOR

takes same panel cut-out as recorder . . . uses many of the same parts. Less spare parts inventory is required. Note the rugged construction, easily accessible calibration adjustments. Vertical scale makes it easy to compare set point and measured value. Recorder and indicator chassis are completely interchangeable.



● **REFERENCE DATA: Write for new Bulletin No. 7202.**

For more information circle **77** on inquiry card.

In performance . . .

precision . . .

serviceability . . .

Tel-O-Set instruments

give you extra values

Whenever you're planning graphic process control, plan to take advantage of the extra values built into the latest *Tel-O-Set* miniature instruments. These advanced indicators, recorders and controllers simplify installation, service and replacement problems . . . and give you the top in accurate, flexible performance for controlling temperature, flow, pressure and liquid level.

Installation is easier. Case, chassis and controller are separate units. The case can be shipped separately to the point of installation and fully piped and tested . . . for the air to valve gage, regulator and switch assembly remain with the case. These components are readily removed without need for breaking conduit or electrical connections. Panel shipment is simplified, with chassis and controller going directly to the job.

Service is easier. All major parts of the indicator and recorder are identical and interchangeable. Unitized construction of sub-assemblies permits interchangeability of sections of major assemblies. The chassis can be partially or fully withdrawn and remain completely operative. It can be disconnected without losing manual control. Controllers have single-lever, quick-disconnect switch . . . use simple, gasketed, flat, mating surfaces.

Operation is easier. An integral switch provides external reset feedback, air on automatic position or air on manual position of bypass relay . . . permitting use with any force-balance controller of past or present design. Opposing pointers tell the measured value and set point on prominently marked vertical scales. Control knob and transfer switch are conveniently located at the bottom of the case, where the operator can manipulate them without having his hand obscure vision of the pointers and scale.

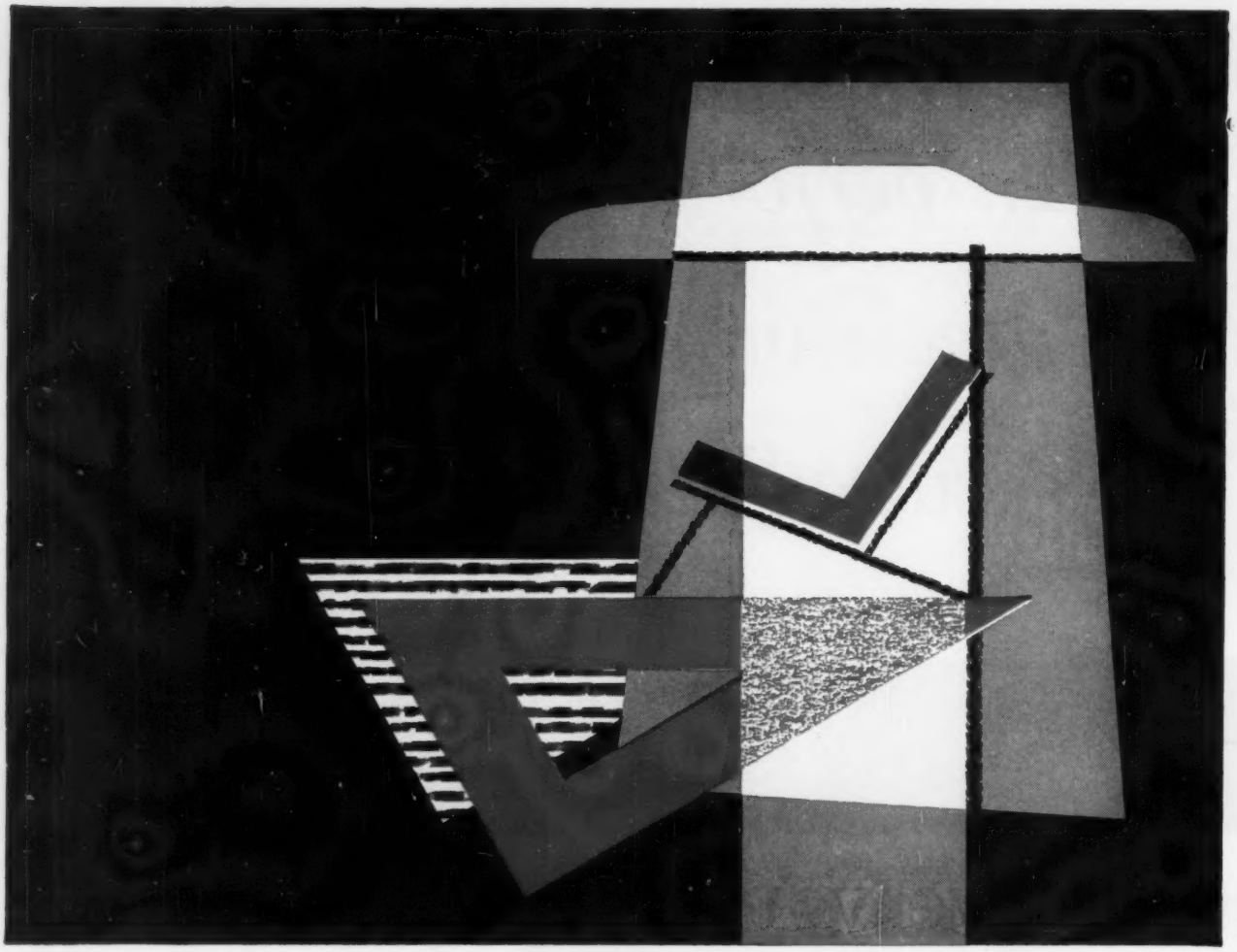
Precision is high . . . ample for even the most exacting process requirements, with true linear calibration.

For a discussion of applications to your own processes, call your local Honeywell sales engineer . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.—in Canada, Toronto 17, Ontario.

MINNEAPOLIS
Honeywell
BROWN INSTRUMENTS
First in Controls

For more information circle **77** on inquiry card.

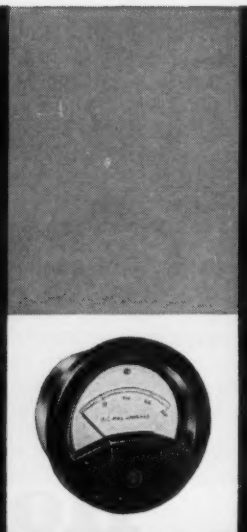


tomorrow's design and styling ... *today!*

The sleek, efficient and streamlined "New Look", which characterizes the styling of Roller-Smith's entire line of indicating instruments, symbolizes the advanced thinking and improvements incorporated in the design of every integral part contained in each and every mechanism.

Specify and install them in your equipment with the complete assurance that —they are every bit "as good as they look".

Whether the instrument you buy is "standard" or must be designed and made to order—be sure its dial bears the name of the master Instrument Makers—Roller-Smith—the epitome of instrument quality for nearly fifty years.



ROLLER-SMITH

Instrument Division

CORPORATION

1825 WEST MARKET STREET ROLLER-SMITH BETHLEHEM, PENNSYLVANIA

Precision Products Since 1908

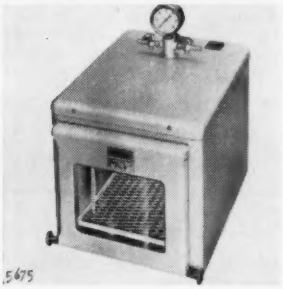
For more information circle **78** on inquiry card.

ers. Temperatures are controlled with thermostats sensitive to 1C°; built-in blower and diffuser walls insure uniform air distribution.—*Labline, Inc.*, 3070-82 *W. Grand Ave., Chicago* 22, *Ill.*

For more information circle **259** on inquiry card.

Vacuum Oven

New "Thelco Model 19" features greater versatility than previous models; has a hydraulic thermostat with

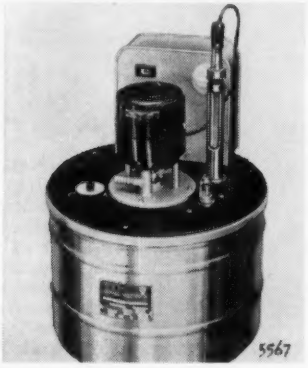


sensitivity of 0.5 C°; reaches maximum temperature (125°C) in 80 minutes.—*Precision Scientific Co.*, 3737 *W. Cortland Ave., Chicago* 47, *Ill.*

For more information circle **260** on inquiry card.

Constant-temperature Circulating System

Newly redesigned "Temp-Trol" for accurate (0.05 F°) temperature control of viscometers, colorimeters, etc.,

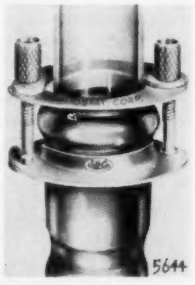


features "Micro-Set" thermoregulator, temperature range from ambient to 210°F, built-in cooling coil, and submerged pump for rapid circulation. —*Precision Scientific Co.*, 3737 *W. Cortland St., Chicago* 47, *Ill.*

For more information circle **261** on inquiry card.

Taper-joint Clamp

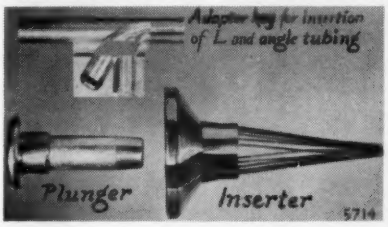
New "Standard Taper" one-piece joint clamp obviates all need for hooks and springs, is of corrosion-proof aluminum construction; has a simple screw adjustment to control clamping pressure; can be easily attached to apparatus already set in place. —*The Emil Greiner Co.*, 20-26 *N. Moore St., New York* 13, *N. Y.*



For more information circle **262** on inquiry card.

Tube Inserter

New "Tube-On," safety device for inserting glass tubes in rubber stoppers, rubber tubing and bulbs, mini-



mizes danger of lacerated fingers or hands; is capable of sleeving most laboratory tubing, either straight or angle, including T, L and Y tubes; is adaptable to angle tubing 1.4 mm to 9 mm diam, straight tubing up to 13 mm or more.—*Central Scientific Co.*, 1700 *Irving Park Rd, Chicago, Ill.*

For more information circle **263** on inquiry card.

Lab Electronic Relay

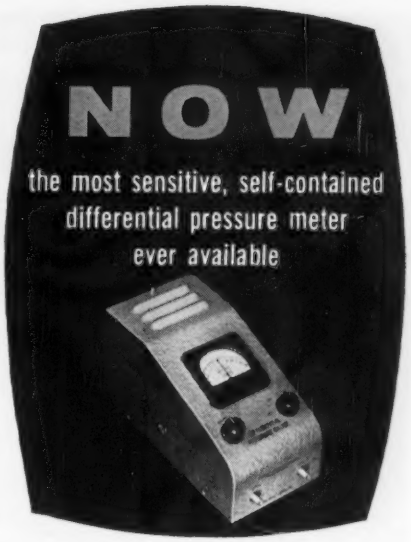
New electronic relay features high (20-amp) load-handling capacity, low control current (e.g. a type 930 pho-

totube), new stable dc circuitry, and a four-way panel selector switch that permits "fail-safe" operation of system in any application. It was designed to eliminate shock hazard when used for water-bath operation. Input terminals and case are completely isolated from ac line and heavy-duty 3-wire line cord incorporates a separate ground lead.—*Arthur S. LaPine & Co.*, 6001 *S. Knox Ave., Chicago* 29, *Ill.*

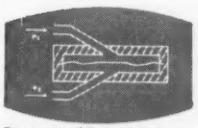
For more information circle **264** on inquiry card.

Laboratory Power Supply

New mobile laboratory power supply transformer unit for on-the-spot availability of any desired output voltage obviates need of frequent changing of circuits and connections and arranging makeshifts. Input: 3-phase 230-250-v 60 cps; two output ranges: 211-640 v 31 amp in 10-v steps, and

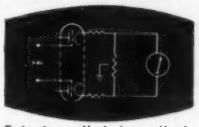


- Measures a wide range of static and dynamic pressure for gas and other non-conducting fluids.
- Determines pressure, volume, and temperature variations, fluid flow, expansion, absorption, adsorption, chemical alterations, altitude, vacuum, etc.
- Provides one micron of mercury resolution at atmospheric pressure . . . 7.5 volts output available for recording at a full scale differential pressure of 1 mm of mercury.



Pressure differential moves beryllium-copper diaphragm.

Ionization transducer converts motion into electrical signal.



Output applied to cathode follower to drive meter.

Two-knob control for balance . . . sensitivity.

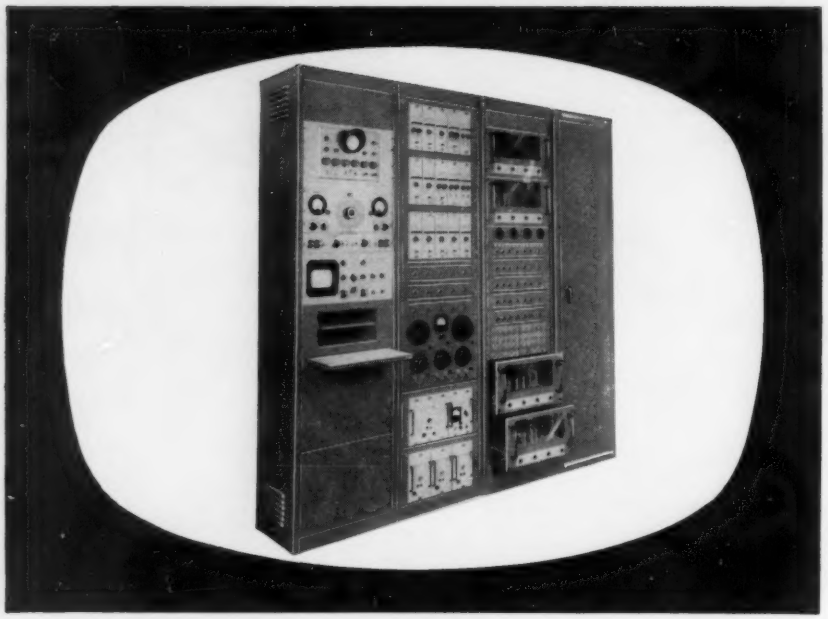
Just plug this compact, completely self-contained meter into a 115V, 60 cy. line and you're *immediately ready for operation*. Based on the famous "T-42" Ionization Transducer, this astonishingly simple pressure instrument, only 5" x 5" x 10" in size, covers the widest range of application. In the laboratory or on the production line, it requires no special accessories, no specially trained personnel.

Details on this new micro-sensitive meter are in Instrument Data Sheet 303-1, available upon request to Technical Literature Section,

DECKER AVIATION CORPORATION
1361 Frankford Ave., Philadelphia 25, Pa.

decker

For more information circle **79** on inquiry card.



Now, An Automatic Production System That Anticipates Change-Orders!

SERVOMATION* BUILDING BLOCKS — a new, unique kind of industrial control technique that enables your production line to turn out both custom and quantity runs with the same cost-saving efficiency.

The Servomation* Building Blocks were designed by Servo Corporation of America at the request of the United States Government to fulfill the need for a truly flexible computer which would serve as a data processing, servosystem synthesizing, and industrial control center. Further development and field testing have brought about an even more flexible and economical system for production control in both large and small industry.

Components Easily Rearranged

Here is a balanced, efficient control system that provides the means for molding your complete manufacturing process into a continuous, total flow operation under automatic control at all times. Yet, it is a control system with inherent flexibility to meet any future procedure changes, no matter how drastic they may be. No Building Block arrangement is limited to its original purpose. The equipment need only be realigned and components rearranged or added to solve your new problems.

Test Laboratory for Designs

Here is a computer system that not only serves as a production control center, but as a workbench for mathematicians and design engineers. You can use the Building Blocks as your laboratory to mock-up and test your intended designs.

SERVOMATION* BUILDING BLOCKS — the only electro-mechanical, computer-control system that performs any or all of these functions:

Production Control — As a collection and computing center, the system will hold machining, position, rate, flow, mixture or temperature tolerances to the limits you specify.

Data Processing — Regardless of how your data is collected, transmitted or stored, Servomation* Building Blocks will efficiently process it.

Design Synthesis — With external patch cord and jack board connections, and the versatile Servoboard® and Servoscope® components, a computer or servosystem design can be easily mocked-up and tested. Closed loop characteristics can be predicted and pre-production "bugs" eliminated.

SERVO CORPORATION *of* AMERICA

New Hyde Park, Long Island, N. Y.

JUST OFF THE PRESS! Descriptive, illustrated booklet on Servomation* Building Blocks. Send for your copy today. Simply request "TDS-2300-6-55" on your company letterhead and mail it to:

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SERVO CORPORATION OF AMERICA 20-14 Jericho Turnpike, New Hyde Park, L.I., N.Y.

For more information circle **80** on inquiry card.

NEW INSTRUMENTS

100-295 v 66 amp in 4-v steps. Adjustment is by 8 fine steps and 8 coarse steps with overlap.—*The Strong Electric Corp., 103 City Park Ave., Toledo 2, Ohio.*

For more information circle **265** on inquiry card.

Laboratory Power Supply

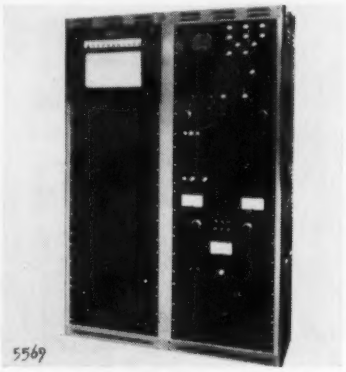
New "Model R-10 Super Regulated Power Supply" is said to combine extremely low noise level (under 50 uv) with close voltage regulation at low cost. Voltage range 200 to 325; currents up to 100 ma.—*Laboratory of Electronic Engineering, 413 L St., N.W., Washington 1, D. C.*

For more information circle **266** on inquiry card.

NUCLEONICS

Pulse-height Analyzers

New "Models 3300 and 3301," of 100- and 256-channel counting capacity, use magnetic-core memory cir-



cuits; are based on Argonne Natl Lab "Model 101" design; are said to feature "unmatched counting efficiency, speed, reliability and ease of operation." Rates of accumulation of data can exceed one million counts per minute (input pulse rates ten times this rate can be tolerated).—*Radiation Instrument Development Lab., 5737 S. Halsted St., Chicago 21, Ill.*

For more information circle **267** on inquiry card.

Prospecting Counters

New "Victor Series" comprises six radiation counters for uranium prospecting and gamma radiation detection. Each model utilizes a basic ratemeter unit incorporating batteries, high-voltage power supply, amplifying, metering, and associated circuitry. Basic unit combines with one or more detecting units of either Geiger-tube or scintillation-probe type. Both types are designed for use as hand probes as well as for internal mounting in instrument case. Combination counters with two detectors are available in two models. All models offer 14 overlapping sensitivity ranges from 15 to 30,000 cps, continuously-variable time constant between ½ and 10 seconds, uranium-thorium ore differentiation testing, and weight under 6 lb.—*Victoreen Instrument Co., 5806 Hough Ave., Cleveland 3, Ohio.*

For more information circle **268** on inquiry card.

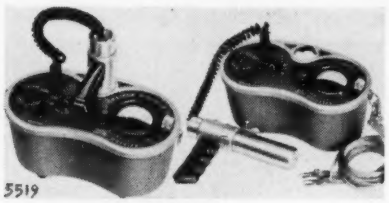
Prospecting Counter

New "No. 402 Walking Stick Geiger Counter" includes maker's "miracle transistorized audio," is said to be "a highly sensitive professional instrument unconditionally guaranteed to stand up under rugged field conditions." Weight 3 lb, length 40 in, diam less than 2 in.—*Universal Atomics, Inc.*, 19 *E. 48th St., New York* 17, *N. Y.*

For more information circle **269** on inquiry card.

Prospecting Counter

New "SC-102" scintillation counter for uranium and oil prospecting assays ore samples at the site, functions



in plane at speeds to 175 mph, 300 ft above ground. All delicate electronic components shock-mounted and protected by non-breakable casing and high grade aluminum; waterproof seals, etc. Sensitivity ranges 0.003, 0.01, 0.03, 0.1, 0.3 and 1 mr/hr; accuracy better than 5% of full-scale. —*Chatham Electronics, Div. Gera Corp., Livingston, N. J.*

For more information circle **270** on inquiry card.

PHOTOGRAPHY

Laboratory Camera

New "Alpa" Swiss-made 35-mm single-lens reflex camera is available with "Macro-Kilar" 40mm f/3.5 lens for general use, wide angle shots as well as close-up (macro-) photography. Extreme extension range of lens mount allows ground-glass focusing from infinity down to 4" distance (Model E) or 2" distance (Model D) without accessories. This gives a subject-to-negative ratio of up to 1:2 or 1:1 respectively, which is further increased when making enlargements from negative.—*Karl Heitz, Inc.*, 480 *Lexington Ave., New York* 17, *N. Y.*

For more information circle **271** on inquiry card.

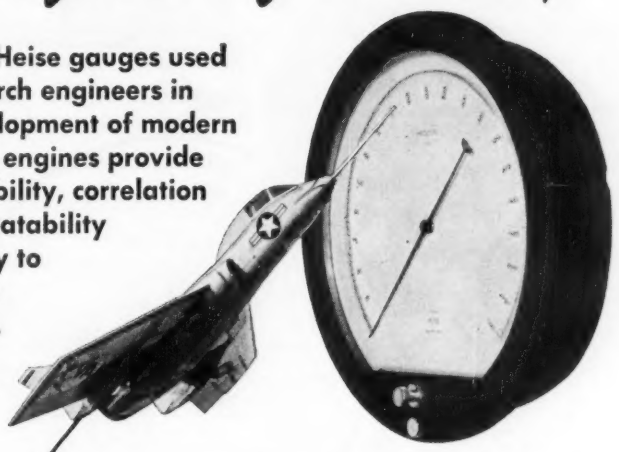
Flash Unit

New "208B" is powered by hermetically-sealed maintenance-free "Dynaseal" rechargeable battery;

HEISE GAUGES

Conquest of the Sky

Heise gauges used by research engineers in the development of modern turbo-jet engines provide the reliability, correlation and repeatability necessary to scientific progress.



Actual operating conditions are reproduced in the Cox Test Stand built by Commercial Research Laboratories to test for optimum efficiency of jet fuel nozzles.

The six Heise gauges incorporated in the test stand feature in the vital and exacting performance which this instrument must accomplish.

Higher air speeds, rates of climb and economic fuel consumption, factors which every day reach and surpass new levels of efficiency, are made possible by the continuing efforts of research men equipped with today's most accurate instruments.

Pressure Ranges 15 to 20,000 P.S.I. Dial Sizes 8½"-12"-16"

Prices from $151.60.

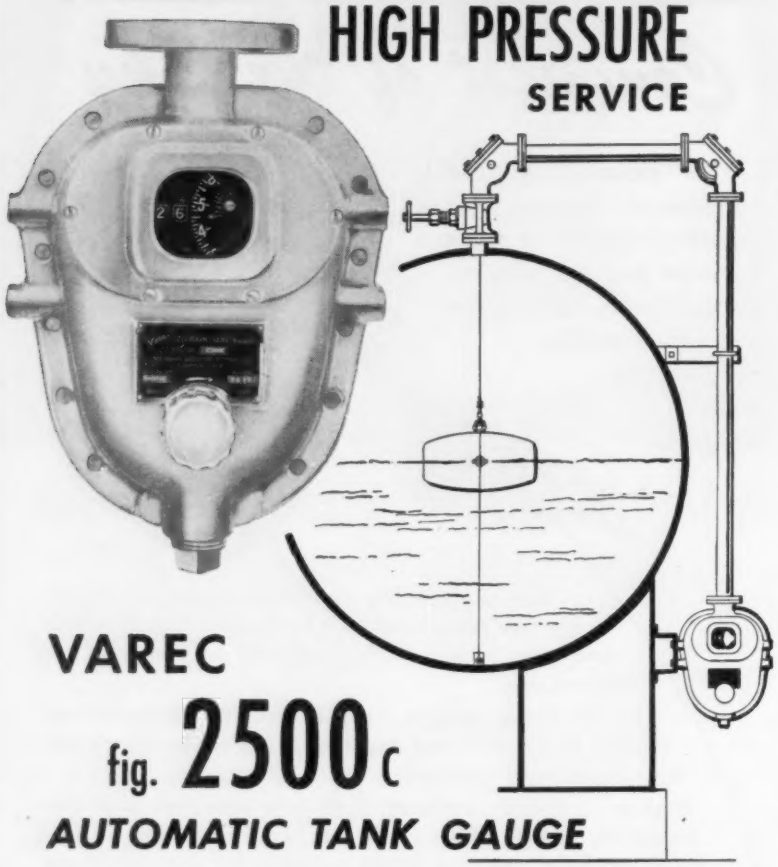
DELIVERY WITHIN 30 DAYS.

HEISE BOURDON TUBE COMPANY, INC.

BROOK ROAD, NEWTOWN, CONNECTICUT, U.S.A.

For more information circle **81** on inquiry card.

NOW- Available for HIGH PRESSURE SERVICE



VAREC fig. 2500C AUTOMATIC TANK GAUGE

Service in working pressures to 300 p.s.i.g. is offered by the new VAREC Figure 2500C Automatic Tank Gauge. It's a high pressure model of the successful VAREC Figure 2500 Series, equipped with the Neg'ator motor, which eliminates use of counterweight and simplifies installation. This series has been tested by 3 years of service in the Petroleum and Chemical fields, after 2 years of experimental and development work.

An important part of this new model is the magnetic drive, which requires no packing gland or mechanical seal on rotating shaft. The use of stainless steel ball bearing construction throughout provides a combination that reduces friction to a minimum.

Liquid level indication on a mechanical counter and dial for convenient, easy reading. Components are enclosed in a separate compartment to keep tank vapors from fogging dial. Operation checker is standard equipment.

Like the low pressure series Figure 2500 gauges, addition of remote gauger transmitter or control devices is a simple field installation. It is not necessary to remove the gauge head or disturb the original installation in any way.

"Varec"

VAPOR RECOVERY SYSTEMS COMPANY
2820 North Alameda Street
Compton 1, California

961-9

Cable address: VAREC COMPTON Calif. (U.S.A.) All Codes

For more information circle **82** on inquiry card.

NEW INSTRUMENTS

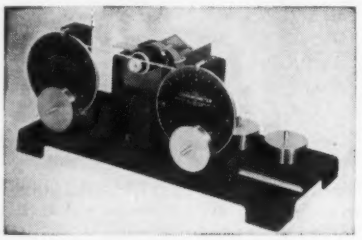
1/2500-sec flash gives positive action stop; is said to produce "twice the light of other comparable units."—*Dormitzer Electric & Mfg. Co., Inc., Cambridge 40, Mass.*

For more information circle **272** on inquiry card.

MECHANICAL TESTING

Dynamometer

New "Model 10-B" subfractional-hp dynamometer facilitates precision torque measurements on small instru-



ments and components. It measures torques between 0.1 and 15 oz-in at any speed when power developed is 20 watts or less. Accuracy 3% of any reading.—*Bischof Die and Engraving Co., 1405 16th St., Racine, Wis.*

For more information circle **273** on inquiry card.

Strain-gage Calibrator

New "Aminco Strain-gage Calibrator," for precise calibration of strain gages, load cells, proving rings, and similar measuring devices, is a primary calibrator that is virtually frictionless, simple in principle and construction, and widely adaptable to various applications. It comprises a thrust load generator and a pressure balance connected by means of high-pressure tubing. Total loads up to 200,000 lbs.; clear opening 4½" wide by 12" high; total piston rise ¼".—*American Instrument Co., Inc., Silver Spring, Maryland.*

For more information circle **274** on inquiry card.

Hardness Tester

New "Model ST 5 Peabody Portable Hardness Tester" weighs 7 oz, features precision tolerances and micro

finishes that match Rockwell and Brinell laboratory test block accuracy from 20 to 65 Rockwell C and Brinell 3000-kg load equivalents; is claimed to be "by far the most accurate and sensitive portable ever developed for the metal working industry." Accessory equipment includes test stand and carrying case.—*Mechanical Devices, Inc.*, 19343 Harper Ave., *Detroit 36, Mich.*

For more information circle **275** on inquiry card.

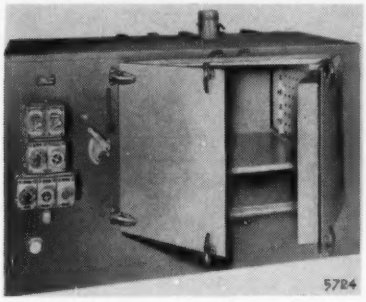
Walk-in Test Chamber

New "Walk-in Type Environmental Test and Storage Chamber" is a small prefabricated room, supplied as a complete package, ready for quick and easy 2-man installation. Temperature range −120°F to 250°F; humidity from 20% to 95% between 35 and 185°F. Optional equipment includes anterooms, viewing ports, program controlling of temperature and humidity.—*Webber Mfg. Co., Inc., 2740 Madison Ave., Indianapolis, Indiana.*

For more information circle **276** on inquiry card.

Explosion-resistant Ovens

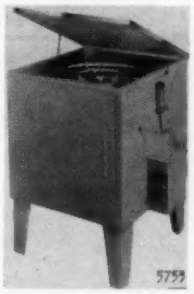
New "Explosion Resistant Ovens," for use where ambient as well as oven-chamber atmosphere is contaminated with inflammable and explosive vapors, are constructed in floor and table models and in two temperature ranges to 260°C. Chamber capacities 1 to 18 cu ft.—*Electric Hotpack Co., Inc., 5029 Cottman St., Philadelphia, Pa.*



For more information circle **277** on inquiry crad.

Humidity Cabinet

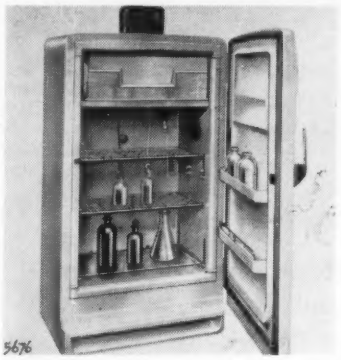
New "Corrosion Test Humidity Cabinet," for testing effectiveness of corrosion-preventive materials according to JAN-H-792, operates at 120°F; is about 28" x 28" x 28" deep, with immersion heaters, air manifold with diffusers, and revolving rack rotating at ⅓ rpm holding 33 test panels.—*Labline, Inc., 3070-82 W. Grand Ave., Chicago 22, Ill.*



For more information circle **278** on inquiry card.

Low-temperature Cabinet

New model of "B. O. D. Incubator," now known as the "Dual Range," features a unique control system whereby heater and cooling system cycle against each other at near-room temperatures, providing cabinet with two temperature ranges: low range from 5° above freezing to 5° above room, and a high range from 5° above room to 50°C. Among other improvements is 0.5 C° temperature uniformity even at near-room temperature.—*Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.*

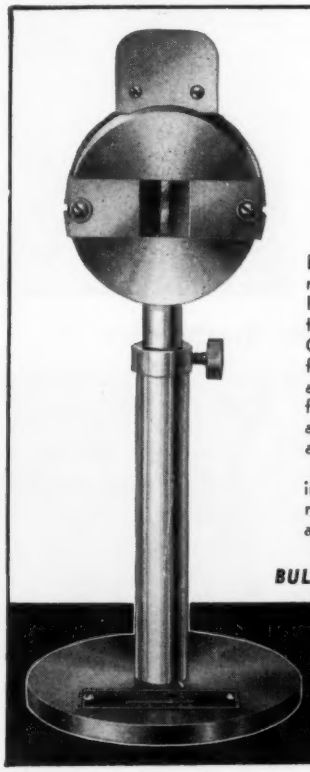


For more information circle **279** on inquiry card.

Compression-spring Tester

New portable compression-spring tester, for production lines, receiving and inspection departments, is said to be lowest priced spring tester of 250-lb capacity on the market. Loads are shown in both lb and kg on a 4-in diam dial and lengths are shown in inches and mm on a two-color etched-metal rule.—*The Carlson Co., 277 Broadway, New York 7, N. Y.*

For more information circle **280** on inquiry card.



EPLAB

Thermopiles

For many years the thermopile has been the accepted instrument for measuring Radiant Heat from Radiant Heaters at the American Gas Association Testing Laboratory in Cleveland, Ohio. Since 1930, when Vandaveer first described his work in this field,* an Eppley thermopile has been used for this purpose in hundreds of tests and the results have been consistent and accurate to within 1 per cent.

This is but one of many applications in the field of radiant energy measurements for which Eppley Thermopiles are ideally suited. They may be obtained with windows of different materials, and various types of black are available for receiver coatings.

All Eppley Thermopiles are supplied with a certificate of calibration, this calibration being made against a Standard Lamp from the National Bureau of Standards.

If you have a problem involving the measurement of radiant energy we invite you to write us, describing your problem in as much detail as possible. We will be glad to make recommendations and there will be no obligation.

*Vandaveer, Industrial & Engineering Chemistry, Vol. 22, page 596, June 1930.

BULLETIN No. 3 ON REQUEST—Address: 2 Sheffield Ave., Newport, R. I.

THE EPPLEY LABORATORY, INC.

SCIENTIFIC INSTRUMENTS

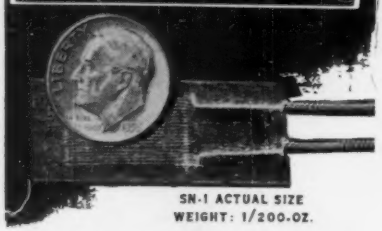
NEWPORT, RHODE ISLAND, U. S. A.

For more information circle **C3** on inquiry card.

RESISTANCE THERMOMETER ELEMENTS

rapid response . . . amazing accuracy

RdF STIKON®



SN-1 ACTUAL SIZE
WEIGHT: 1/200-OZ.

Intended for surface temperature measurement and control, an RdF Stikon consists of a temperature-sensitive grid of very fine nickel wire bonded into a paper-thin wafer of flexible insulating material. Attached by cement to almost any surface anywhere, an RdF Stikon is unaffected by shock or vibration. The response is extremely fast and accurate.

Features of RdF Stikons

BN-1: Response fits curve defined by A-N Specification MIL-B-7990.
BN-3 & BN-4: Similar to BN-1 but smaller in size. Response curve differs from BN-1.
PN-1 & PN-2: Paper construction for low cost.
SN-1: High-temperature element.

SUMMARY OF CHARACTERISTICS

Type	Resistance at 70°F (ohms)	Temperature Range F*
BN-1	81.7	−100° to +300°
BN-3	50.	−100° to +300°
BN-4	200.	−100° to +300°
PN-1	50.	−100° to +180°
PN-2	200.	−100° to +180°
SN-1	100.	−100° to +500°

*For continuous operation — may be used intermittently at higher temperatures. See RdF Stikon Brochure T-54.

Type	Wafer Material	Size (Inches)
BN-1	Bakelite	½ x 1½ x .005
BN-3	Bakelite	5/16 x ¾ x .006
BN-4	Bakelite	5/16 x ⅞ x .006
PN-1	Paper	5/16 x ¾ x .006
PN-2	Paper	5/16 x ⅞ x .006
SN-1	Silicon-Glass	5/16 x 1 1/16 x .010

Types BN-1, BN-3 and PN-1 are marked to 0.2 ohms, while types BN-4, PN-2 and SN-1 are marked to 0.5 ohms.

In addition to the standard RdF Stikons tabulated above, Arthur C. Ruge Associates, Inc. manufactures special resistance thermometer elements tailored to specific customer needs.

Write today for RdF Stikon Brochure T-54.

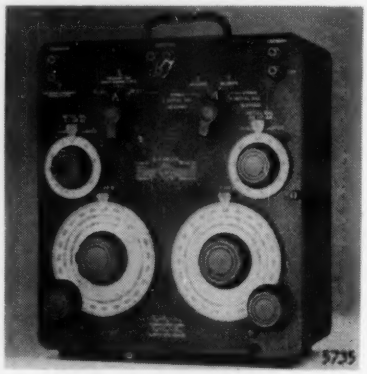
ACRA
Arthur C. Ruge Associates, Inc.
733 CONCORD AVE
CAMBRIDGE 38, MASS

For more information circle **84** on inquiry card.

ELECTRICAL TESTING

A-f Impedance Bridge

New "Type 1603-A Z-Y" is said to possess "the almost unbelievable characteristic that it can be balanced for



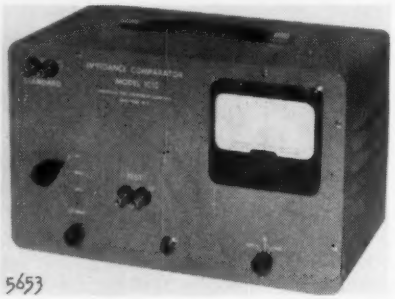
any impedance connected to its terminals. From short circuit to open circuit, real or imaginary, positive or negative, a bridge balance can be obtained with ease."—*General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.*

For more information circle **281** on inquiry card.

Resistance, Capacitance and Inductance Tester

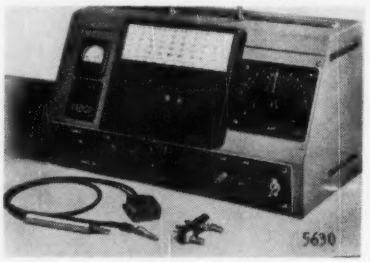
New "Model 1010 Impedance Comparator," for rapid testing of resistors, capacitors, and inductors, has three full scale ranges: ±5%, ±10%, ±20%. Impedance limits: resistance 5 ohms to 5 megohms; capacitance 50 mmfd to 20 mfd; inductance 100 microhenry to 80 henry. Two operating frequencies: 1000 and 10,000 cps.—*Industrial Test Equipment Co., 55 E. 11th St., New York 3, N. Y.*

For more information circle **282** on inquiry card.



Capacitance-&-inductance Tester

New "C-L Meter" is said to make possible determination of capacitance and inductance under conditions of



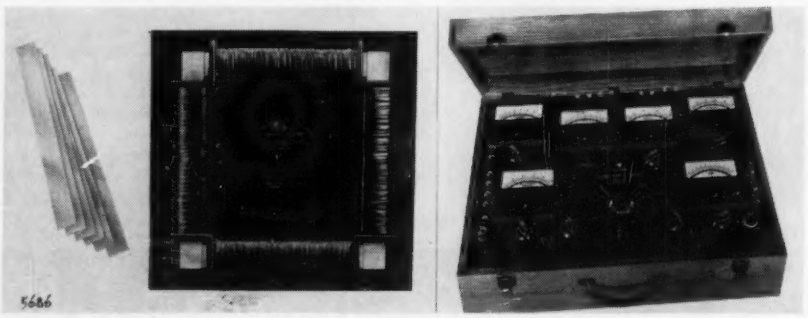
actual use with lab precision and production-line ease. Its probe permits values of installed components to be actually measured instead of merely assumed. Production jigs are easily attached to front panel jacks. A test adapter is furnished for convenience in testing capacitors and small coils.—*Erdco Engineering Corp., Westgate Dr. & Official Rds., Addison, Ill.*

For more information circle **283** on inquiry card.

Capacitance-&-inductance Tester

New "Model 402B Dynamic Micrometer" is said to be a unique device for measuring capacitances and inductances in operating circuits, as well as for static measurement of

Universal Magnetic Testing Set



New Universal Magnetic Testing Set is a complete unit designed to make measurements that conform to ASTM methods and specifications. Functions: determining *BH* curves; determining hysteresis loops; core loss testing using Epstein frame or standard "E" and "I" cores; measuring total flux of hard magnets; measuring magnetic field strength; ac and dc permeability tests.—*Sensitive Research Instrument Corp., 9 Elm Ave., Mount Vernon, N. Y.*

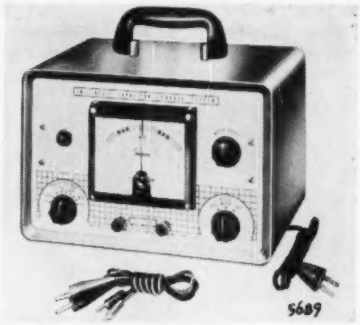
For more information circle **284** on inquiry card.

small components. Maker's special circuit, employing quartz crystal reference, assures accurate operation over long service life.—*Kay Lab.*, 5725 *Kearney Villa Rd., San Diego* 12, *Calif.*

For more information circle **285** on inquiry card.

Capacitor-leakage Tester

New "Model 383" shows presence or absence of leakage in virtually all paper, mica, or ceramic capacitors



while connected in circuit, eliminating disconnecting and resoldering; checks capacitors from 1 uuf to 0.25 uf for leakage from a few ohms to hundreds of megohms, at full rated working voltage, also detects presence of unstable resistors in circuit.—*Simpson Electric Co.*, 5200 *West Kinzie St., Chicago* 44, *Ill.*

For more information circle **286** on inquiry card.

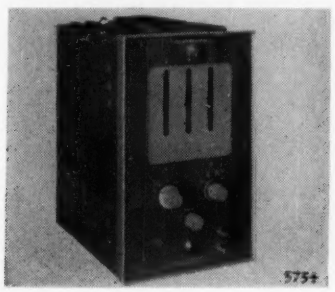
High-voltage Testers

New "Type PA-50 High Voltage AC Breakdown Tester" permits tests from 0 to a maximum of 100,000v continuously variable; incorporates same features of maker's "Model PA-5" such as automatic rate of rise with any ASTM rate, etc.; is rated at 5 kva available at breakdown. Wide variety of testing jigs available.—*Industrial Instruments, Inc., Cedar Grove, N. J.*

For more information circle **287** on inquiry card.

Digital Indicator

New "Model 503 Digital Multitester" is a new type of high-precision test instrument which measures dc volts, ac volts, and ohms; and uses



A DOUBLE BARRELLED TROUBLE SHOOTER

PANALARM "50VS"

VISUAL SEQUENCE ANNUNCIATOR*

1 **VISUALLY INDICATES**
first "off-normal" and subsequent "off-normals".

2 **SEQUENTIALLY GROUPS**
related variables for easy interpretation.

Troubleshooting in complex processes can be expensive and time consuming. The Panalarm "50VS" Visual Sequence Annunciator *eliminates guesswork . . . pinpoints trouble.* It immediately flashes the cause of trouble; instantly shows resultant "off-normals", and provides a means of grouping and acknowledging related variables so that minimum interpretation is required . . . quick, direct corrective action can be immediately taken.

Your present Universal Panalarm "50" Annunciator System can be changed to provide visual sequence signals. This flexibility prevents obsolescence . . . has made the Panalarm "50" the most versatile audio-visual annunciator available today.

PANALARM "50VS" gives CONTROL INFORMATION

- **The primary cause of trouble . . .**
- **Secondary "off-normals" resulting . . .**
- **Sequential follow-up of "off-normal" . . .**

Send for Bulletin 6-A.
LISTED BY UNDERWRITERS' LABORATORIES

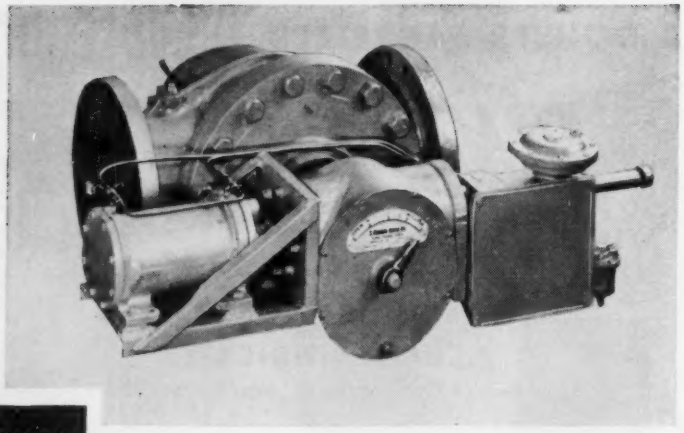
PANALARM
Alarm and Safety Division

PANELLIT, INC.
7405 N. Hamlin Avenue, Skokie, Illinois

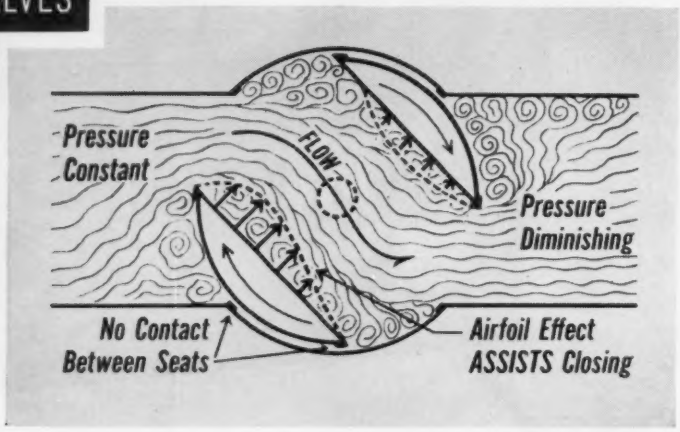
PANALARM
PANELLIT

*U.S. Patent No. 2701872 Copyright 1955, Panellit, Inc.

For more information cricle **85** on inquiry card.



SMS ROTOVALVES



Hydraulic Imbalance Makes SMS-Rotovalves EASY TO OPERATE

SMS-Rotovalves are easier to open and close. As shown above, hydraulic imbalance creates a strong airfoil effect to help ease closing. Regulation can be fast or slow to suit process needs.

SMS-Rotovalves give complete control in all positions of an extremely wide operating range. Turndown is so great that one Rotovalve can often replace two, or three conventional valves. Pumping costs are cut, for a full open Rotovalve has no more pressure drop than an equivalent length of pipe of the same diameter.

S. Morgan Smith offers you complete valve engineering service. For information on our entire line of cone, ball and butterfly valves and their suitability for the varied demands of your control problems, see your local representative, or write to S. Morgan Smith Company, York, Pennsylvania.

Hydraulic Turbines — Gates & Hoists
Pumps — Trash Rakes
Accessories

HYDRODYNAMICS

Rotovalves — Free-Discharge Valves
Ball Valves — Controllable-Pitch Ship Propellers
Butterfly Valves

S. MORGAN SMITH CO.

AFFILIATE: S. MORGAN SMITH, CANADA, LIMITED, TORONTO

For more information circle **86** on inquiry card.

three columns of electronic decade counters with neon light display as indicator. Accuracy: on dc range 0.15% of full scale, on ac 1% and on ohms 0.2%. Ranges 0.01 to 1000 v and 10 ohms to 10 megohms.—*Laboratory for Electronics, Inc., 75 Pitts St., Boston 14, Mass.*

For more information circle **288** on inquiry card.

Frequency-selective VTVM

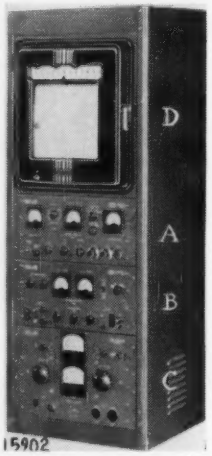
New "Model 21 Wave Analyzer" is a frequency-selective vacuum-tube voltmeter that measures amplitude

and frequency of electrical signal components within unusually broad range of 30 to 50,000 cps. Full-scale readings 500 v down to 160 microvolts rms. Main features: a precise double half-lattice crystal filter and a switch for choosing either narrow or broad selectivity.—*Donner Scientific Co., 2829 7th Street, Berkeley 10, Calif.*

For more information circle **289** on inquiry card.

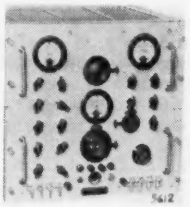
Power Supply Test Set

New "Power Supply Test Set" comprises: (A) "Model 901 Power Supply Regulation Analyzer" designed to measure an applied direct voltage to 0.1%, percentage change in this applied dv, and rms ripple on applied dv of regulated and unregulated power sources. Test range 1.018 to 1112 vdc; three ranges for measuring percent regulation; eleven ranges for measuring rms ripple. (B) "Model 910 Power Supply Variable Load" consists of an electronic load covering range 60-600 v 0-600 ma, and a resistor load covering range 0-100 v 0-600 ma; either load automatically modulated; (C) "Model 920 Line Voltage Adjuster" provides adjusting line voltage from 95 to 135 vac for any fixed input voltage in range 95-135 vac. Capacity 3 kva. (D) Standard-make recording potentiometer, for logging regulation and stability characteristics.—*Kepco Labs, 131-38 Sanford Ave., Flushing 55, N. Y.*



For more information circle **290** on inquiry card.

Signal Generator

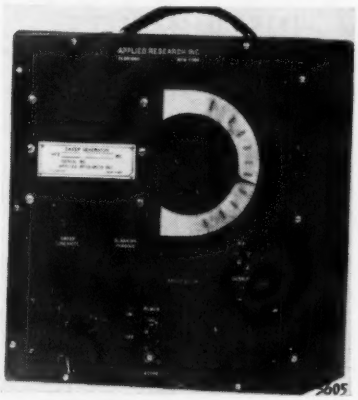


New "USM-16" multi-purpose self contained signal generator for general laboratory use (or for maintenance where extreme accuracy is required) provides multi-purpose modulation including CW, AM, FM, PM, and sweep. Can be tuned to within less than 1000 cps of desired frequency between 10 and 440 Mc with two-stage temperature-controlled crystal calibrator. Frequency drift, after warm-up, less than 0.002% in eight hours at room temperature.—*Byron Jackson Electronics, 492 E. Union St., Pasadena, Calif.*

For more information circle **291** on inquiry card.

Sweep Generators

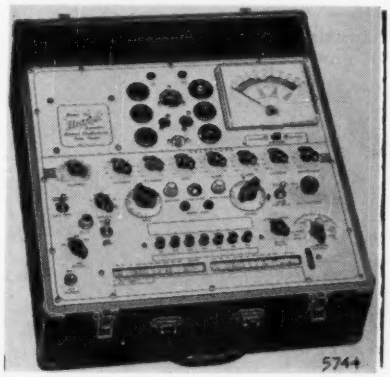
Two new "Type HFS Broadband Sweep Generators": "Model HFS-1319" simultaneously displays frequency range of 1350 to 1950 Mc; "Model HFS-813" 845 to 1375 Mc. Both provide advantages of rapid design, alignment and test of systems and components within L Band frequency range. Concept of lumped-constant and distributed-constant multiple-tuned circuits "leaves realm of theory and becomes practical working units." Typical Tschebycheff or Butterworth response curves are available.—*Applied Research, Inc., 163-07 Depot Rd., Flushing, N. Y.*



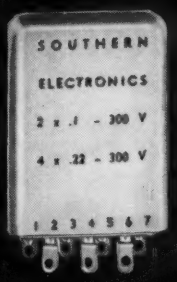
For more information circle **292** on inquiry card.

Engineer's Tube Tester

New "Model 750" is a field engineer's dynamic mutual conductance type tube checker; incorporates all



Condense and Save!

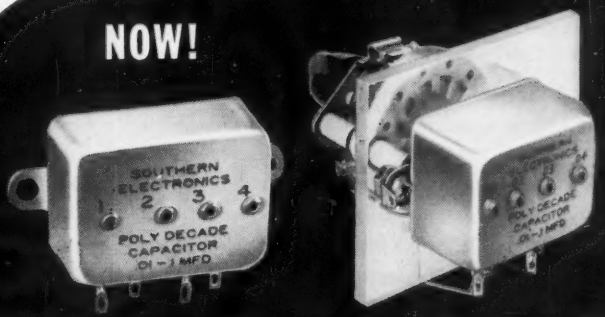


plastic condenser block capacitors save you Space, Labor, Money!

Multiple capacitors in **one** block! Now you can install one capacitor case and use 125% less space as before —at a saving in labor costs of up to 300%.

Available with polystyrene or MYLAR* dielectric to tolerances as close as 1%.

NOW!



Precision Decade Capacitors

with attached rotary switch or completely boxed.

CAPACITANCE ... FROM .001 TO 10 M F D

CHECK THESE OUTSTANDING FEATURES:
- STANDARD VOLTAGE RATING . . 200 V. D. C.
- VERY HIGH INSULATION RESISTANCE
- LOW DISSIPATION FACTOR
- LOW DIELECTRIC ABSORPTION
- SMALL SIZES

Available with polystyrene or MYLAR* dielectric to tolerances as low as 1%.

*DuPont T.M.

Join America's leading electronic equipment manufacturers in specifying Southern Electronics' precision polystyrene capacitors for your most exacting requirements. Write for complete catalog today!

SOUTHERN ELECTRONICS Corporation

239 West Orange Grove Ave., Burbank, Calif.

For more information circle **87** on inquiry card.

every indication points to ELINCO

SELF-SYNCHRONOUS UNITS for remote indication and control of

FLUID LEVEL
DIFFERENTIAL MEASUREMENT
PRESSURE
POSITION
MOTION
ANGULAR DISPLACEMENT

Cost-saving Elinco Commercial Type Units are right by every indication — just what you need for day-in-day-out use, or for special indicator-control applications — yet you save up to half the usual cost with Elinco —

★*Motors and Generators* for direct "back-to-back" indicator installations

★*Resolvers* for use in torque amplification and servo control systems where extreme accuracy is not required

★*Phase Shifters* where "sensing" must be expressed as a phase relationship

★*Rotatable Transformers* where rotor displacement varies voltage output, for process control and similar applications

FEATURES AND SPECIFICATIONS — Every Elinco unit is a precision instrument manufactured to highest standards, 100% electrically tested, individually balanced dynamically and statically, and carefully produced under step-by-step quality control of all components.

Type	Dimensions	Accuracy	Torque at Max. Phase Displacement	Torque Gradient within ±10° Displacement
Midget	2½" dia. x 3"	3°	2.5 oz. in.	.03 oz. in./deg.
FB	2½" dia. x 4"	2°	4.2 oz. in.	.053 oz. in./deg.
A	3⅜" dia. x 6⅜"	1°	18.0 oz. in.	.28 oz. in./deg.

All above types have 115-volt, 60-cycle primaries, 34-volt secondaries. Special units can be supplied with accuracies, torques, and electrical characteristics to order.

When you specify Elinco Self-synchronous Units, you not only save substantially, but you receive units made by specialists with years of experience producing instrument-type rotary electrical equipment, outstanding for efficient design, precision, and quality. Send us your specifications . . . let us go to work for you now.

COMMUTATOR MOTORS ★ AC MOTORS ★ AC and DC GENERATORS ★ SPECIAL ROTARY UNITS

Custom manufactured in a variety of types to meet individual specifications for precision instrument and control applications. Write for catalogs.

ELECTRIC INDICATOR COMPANY, INC.
106 Camp Avenue • Springdale, Connecticut

ELINCO

For more information circle **88** on inquiry card.

latest features for testing all tubes encountered in all phases of electronic work including latest ruggedized types and new series heater-string (600-ma) tubes, also germanium diodes and selenium rectifiers.—*The Hickok Electrical Instrument Co., 10519 Dupont Ave., Cleveland 8, Ohio.*

For more information circle **293** on inquiry card.

Low-cost Growler

New "Model G-219" is equipped with an indicating instrument and test prods for measuring armature output, and for checking shorts, grounds, high resistance, number of turns, brush holders, terminal posts and generator field windings. Growler jaws are said to be adequate for both generator and starter armatures. —*King Electric Equipment Co., Cleveland, Ohio.*

For more information circle **294** on inquiry card.

ELECTRICAL INSTRUMENTS

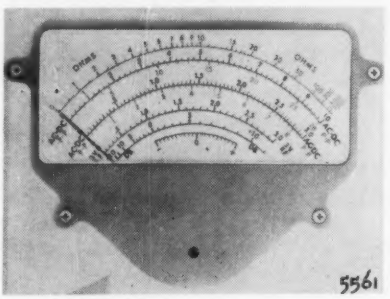
Digital Voltmeter

New "Model 451" four-digit stepping-switch type voltmeter is said to provide automatic measurement and digital display of d-c voltages "at less than half the cost of comparable previously-available instruments." It operates as a self-balancing digital potentiometer. Oil-immersed stepping switches are life-tested for 20 million readings. Polarity indication and decimal shifting are automatic. Accuracy essentially equal to resolution at all times is obtained by calibration to internal bank of nine Weston standard cells. Reference voltage for measurement is supplied by mercury cells (operating life over 1000 hr).—*Non-Linear Systems, Inc., Del Mar Airport, Del Mar, Calif.*

For more information circle **295** on inquiry card.

Behind-panel-mounting Instrument

New "SS56" is a "plexi"-covered indicating instrument of p-m m-c type with a 6" x 2½" dial face; is designed



for mounting behind equipment panel; is also supplied with provision for internal scale illumination.—*Marion Electrical Instrument Co., Manchester, N. H.*

For more information circle **296** on inquiry card.

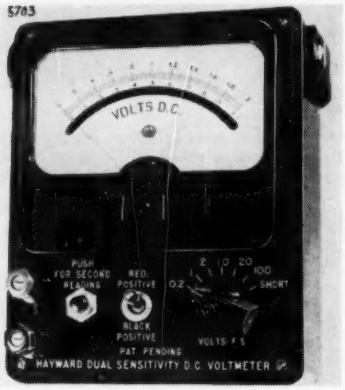
Panel Instruments

Two new lines of rectangular panel instruments, 4½" and 5½" in size, are announced. 5½" instruments are available in three types: dc, rf, and ac rectifier; each with external-magnet movements, or shallow or deep core magnet movements. 4½" instruments are available in the same three types, with either shallow or deep core magnet meter movement. Both sizes are available in standard black Bakelite cases, or in maker's new modernistic black Bakelite cases with chrome trim. Sensitivities as low as 10 uamp; all practical ranges.—*The Simpson Electric Co., 5200 W. Kinzie St., Chicago 44, Ill.*

For more information circle **297** on inquiry card.

Dual-sensitivity VM

New "Hayward Model 610 Dual Sensitivity Voltmeter" for corrosion control and cathodic protection work



comprises a voltmeter movement having two different sensitivities. D.c voltage ranges of 0-0.2/1/2/10/20/100 are provided as well as a "short" position for carrying instrument. No tubes or batteries are used or required.—*Associated Research, Inc., 3767 W. Belmont Ave., Chicago 18, Ill.*

For more information circle **298** on inquiry card.

Null Indicator

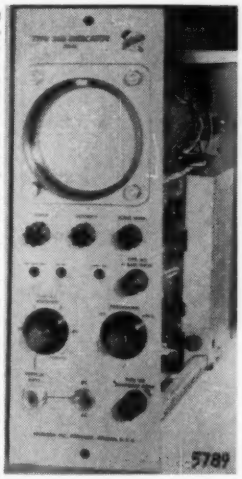
New "Type 1965" electronic galvanometer for bridge and potentiometer measurements is unaffected by vibration, has response time of less than 1 second and current sensitivity greater than 2 x 10^{-10} amp. Voltage

sensitivity is better than 1 uv/mm scale division. This high sensitivity, and instrument's high input impedance (5,000 ohms), are advantageous for measuring high resistances.—*Shallcross Mfg. Co., Collingdale, Pa.*

For more information circle **299** on inquiry card.

CRT Indicator

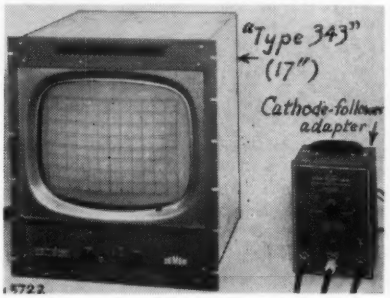
New "Type 360" indicator contains a 3" flat-faced cathode-ray tube, accelerating-voltage supply, vertical amplifier with a sensitivity of 0.05 v/div, and a calibrated vertical attenuator. It is designed to be powered by a maker's "Type 160" or "160A" power supply and to receive its sweep and unblanking voltages from maker's "Type 162 Waveform Generator"; but can be operated from any source of proper voltages and waveforms.—*Tektronix, Inc., P. O. Box 831, Portland 7, Oregon.*



For more information circle **300** on inquiry card.

Large-screen CR Indicators

New 17" and 21" cathode-ray indicators are for lecturers, demonstrators, engineers and investigators in

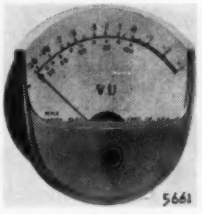


scientific, medical, and industrial fields; are designed primarily for use in conjunction with low-frequency laboratory-type oscilloscopes such as maker's "Types 340, 325 and 333." Coupling to the master 'scope is performed through a cathode-follower adapter (supplied).—*Allen B. DuMont Labs., Clifton, N. J.*

For more information circle **301** on inquiry card.

VU Meter

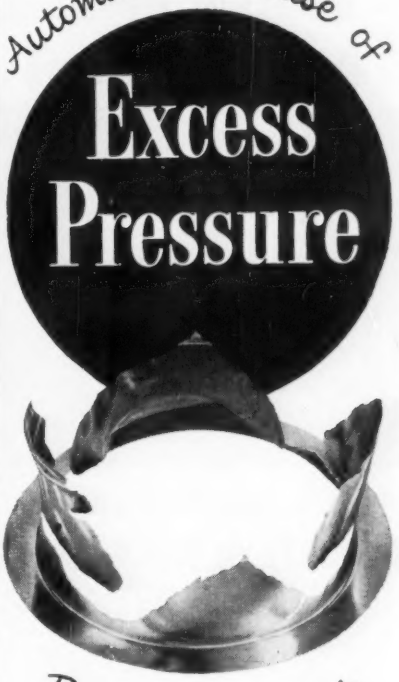
New VU meter features clear Plexiglass case construction admitting light from top, sides, and front; scale length nearly 50% greater than in conventional 2" instruments; meets latest ASA spec C16.5-1954.—*Marion Electrical Instrument Co., Manchester, N. H.*



For more information circle **302** on inquiry card.

Instant Automatic Release of

Excess Pressure



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For more information circle **89** on inquiry card.

NOW... Noise Free A.C. Power!

NEW CURTISS-WRIGHT DISTORTION ELIMINATING VOLTAGE REGULATOR

- Reduces typical power line distortion to less than 0.3%
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- Electronically regulates 115 V output to ±1%
- Recovery time less than 1/50 cycle
- Provides additional 4 KVA of ±1% electromechanically regulated power
- Electromechanical time constant only 0.6 seconds
- Electromechanical regulator, unlike usual magnetic voltage stabilizer, introduces no distortion or phase shift

Here at last is the ideal solution to the disturbing problem of harmonics and low frequency noise appearing in 115 V., 60 cps power sources. In one compact package, every laboratory can now obtain *both*

1) distortion-free, regulated power when needed, and simultaneously

2) a large supply of electromechanically regulated power for applications where normal line distortion is tolerable.

In addition to its general laboratory utility, this instrument is ideally suited for preventing instability and inaccuracy in a.c. computer system nulling operations. Many other applications. 230 V. model also available. Immediate delivery. $1,689 f.o.b. Carlstadt, N. J. Write for details.

Component & Instrument Department

ELECTRONICS DIVISION
CURTISS-WRIGHT
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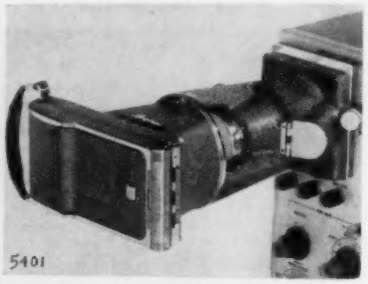
For more information circle **90** on inquiry card.

ELECTRICAL-INSTRUMENT ACCESSORIES

Oscilloscope Camera

New "Recordoscope 1414" provides single-frame photographic records of crt phenomena in 60 seconds; is based

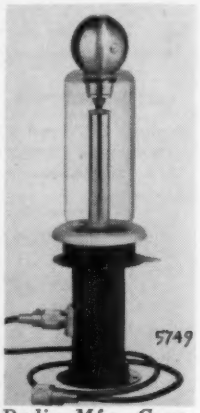


on an adaptation of new small "Polaroid" fast-print magazine; mounts easily on any standard 3-in or 5-in 'scope. Swing-away camera hood and mounting plate are included in package. Speed and facility of mounting enable one camera to serve several 'scopes of various types and makes.—*Aremac Associates, 50 S. San Gabriel Blvd., Pasadena, Calif.*

For more information circle **303** on inquiry card.

H-V Capacitive Probe

New "Model JP-325" high-voltage probe utilizes "Type VDF 2.8 Vacuum Capacitor Voltage Divider" rated at 60 kv peak. Divider output is padded with a ceramic capacitor and is fed into 3' of RG-58 A/U cable so that over-all division ratio is 325 to 1. Input resistance is above 1012 ohms and input capacitance is 4 mmfd.—*Jennings Radio Mfg. Corp., P. O. Box 1278, San Jose, Calif.*



For more information circle **304** on inquiry card.

Pulse Amplifier

New "Type 1219-A Unit Pulse Amplifier" produces pulses at high power levels, with many different

characteristics of duration, duty ratio, and impedance level; can be driven by any available source of positive or negative pulses to produce pulses of current from 600 to 200 ma depending upon duty-ratio.—*General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.*

For more information circle **305** on inquiry card.

Wattmeter Preamplifier

New "Model 150-2300" preamplifier converts an average value of ac watts into a proportional dc voltage suitable for recording; is designed as a front-end for plug-in installation in "Model 150-200 Driver Amplifier" unit used in maker's one-to-eight-channel recording systems.—*Sanborn Co., Industrial Div., 195 Massachusetts Avenue, Cambridge, Mass.*

For more information circle **306** on inquiry card.

Electronic Filters

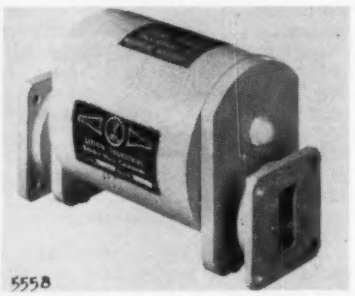
New "Models 330-A and 330-M" variable electronic band-pass filters have gain of unity in pass band (drop outside pass band at rate of 24 db/octave). High and low cut-off

frequencies are independently adjustable from 0.02 to 2,000 cps in "330-A" and from 0.2 to 20,000 cps in "330-M."—*Krohn-Hite Instrument Co., 580 Massachusetts Ave., Cambridge 39, Mass.*

For more information circle **307** on inquiry card.

Microwave Load Isolator

New "Model X20-L," designed especially for laboratory use, is said to provide "significantly higher isolation

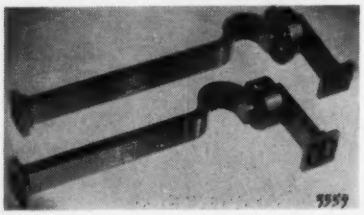


over a wider band of frequencies than previously available units."—*Litton Industries, 336 North Foothill Road, Beverly Hills, Calif.*

For more information circle **308** on inquiry card.

Microwave Rotary Joint

New "Model H250R Rotary X-Band Rotary Joint" provides margin of safety for today's high-powered

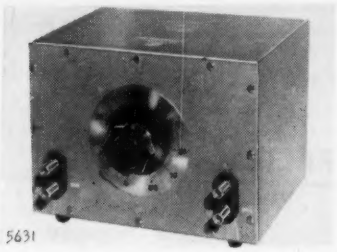


microwave systems. Nominally rated at 250 kw, it does not break down until about 700 kw. Maximum vswr of 1.10 is maintained over 8500-to-9600-Mc band; variations of vswr and phase with rotation are negligible.—*Litton Industries, 336 No. Foothill Road, Beverly Hills, Calif.*

For more information circle **309** on inquiry card.

Variable-delay Network

New "#300 Series," unlike conventional tapped delay which must be terminated in a high impedance at



selected tap, provides a variable delay between matched impedances; is available in ranges of 2 usec to 2000 usec; affords flexibliity in obtaining long delays, with time delay proportional to shaft's angular rotation.—*ESC Corp., 534 Bergen Blvd., Palisades Park, N. J.*

For more information circle **310** on inquiry card.

AMPLIFIERS

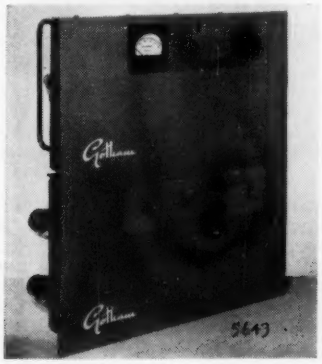
Wide-band Amplifier

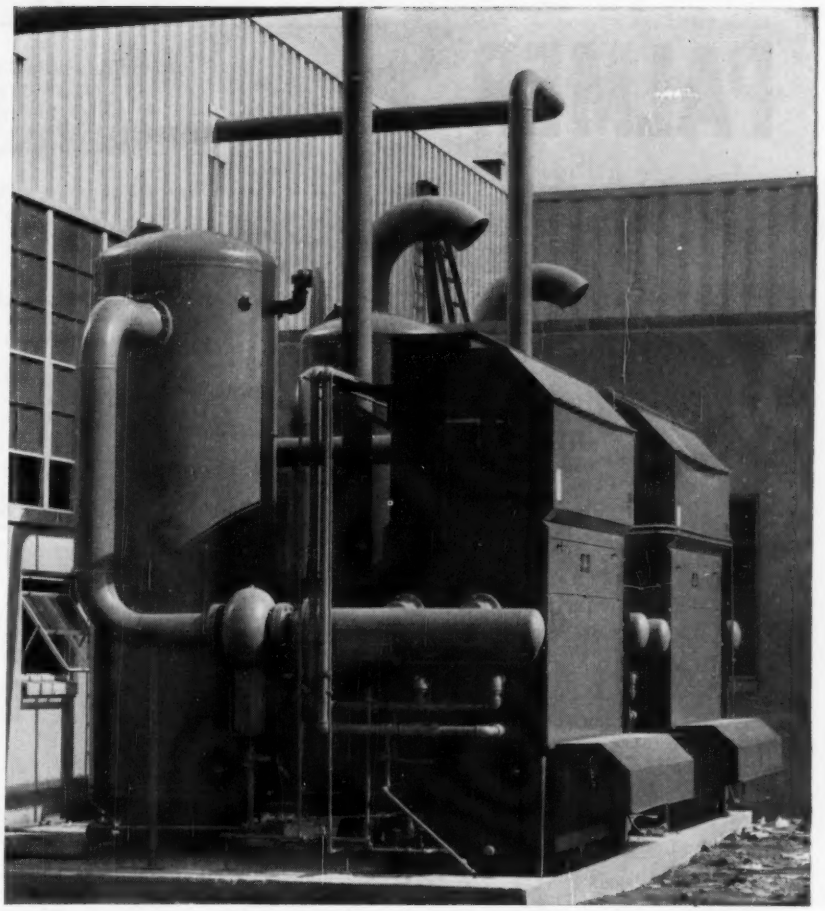
New "Model 854A" provides a choice of two fixed voltage gains of 10 and 100 over frequency range of 10 cps to 1 Mc (usable to higher frequencies with some slight sacrifice in uniformity of response). Distortion less than 1% when operating into recommended loads. Output voltage maximum 10 v into a minimum load of 3000 ohms. Input impedance 1 megohm shunted by about 15 mmf.—*Shasta Div., Beckman Instruments, Inc., P. O. Box 296, Station A, Richmond, Calif.*

For more information circle **311** on inquiry card.

Power Amplifier

New "PFB-150WD" delivers 150 watts with less than 0.7% rms harmonic distortion from 40 to 15000 cps, and 10 watts with less than 0.15% over range 20 to 20,000 cps. Damping factor exceeds 40. Noise level 100 db below 150 watts output. Instantaneous





This Niagara Aero After Cooler also cools compressor jacket and intercooler water.

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THE NIAGARA *AERO* AFTER COOLER offers a completely self-contained method replacing both shell-and-tube cooler and cooling tower. It is independent of a large supply of cooling water and consistently reduces compressed air temperatures to below ambient. Its drier air gives you a better operation and lower costs in the use of all air-operated automatic instruments, tools and machines, paint spraying, sand blasting and moisture-free air cleaning.

Direct saving in the cost of cooling water saves the price of the Niagara *Aero* After Cooler in less than two years. Water saving also means less expense for piping, pumping, water treatment and water disposal, or you get the use of water elsewhere in your plant where it may be badly needed.

Niagara *Aero* After Cooler assures all these benefits because it cools compressed air or gas below the temperature of the surrounding atmosphere; there can be no further condensation in your air lines. It condenses the moisture by passing the air thru a coil on the surface of which water is evaporated, transferring the heat to the atmosphere. It is installed outdoors, protected from freezing in winter, proven in service on the largest plant utility air systems.

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For more information circle **91** on inquiry card.

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Mfrs. of Industrial Laboratory Recording and Dial Thermometers

For more information circle **92** on inquiry card.

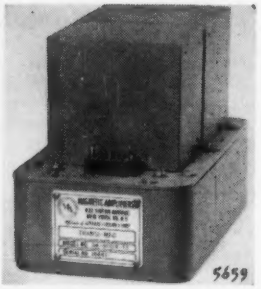
NEW INSTRUMENTS

peak power of 400 watts is available with perfect stability. Output ranges from 25 v at 5 amp to 125 v at 1.2 amp.—*Gotham Audio Development Corp., 2 W. 46th St., New York 36, N. Y.*

For more information circle **312** on inquiry card.

Transistor-magnetic Servo Amplifiers

New "Transi-Mags" feature use of only static components, absence of filaments, high sensitivity and high input impedance with great flexibility in application to servo systems; are available for practically all standard servomotors for operation on 400 or 60 cps.



Ambient temperature range −50°C to 71°C standard; higher-temperature units available.—*Magnetic Amplifiers, Inc., 632 Tinton Ave., New York 55, N. Y.*

For more information circle **315** on inquiry card.

POWER SUPPLIES

HV Power Supply

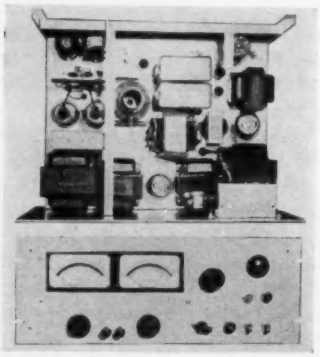
New "N-401 High Voltage Power Supply" provides high degree of stability previously available only with

batteries: stability is limited only by voltage reference tubes (new ultra-stable 85A2 tpes operated under constant current). "N-40" provides continuously-variable voltage from 500 to 1800 at load currents up to 5 ma. *Hamner Electronics Co., Inc., P. O. Box 531, Princeton, N. J.*

For more information circle **313** on inquiry card.

H-v Power Supply

New "No. R-500A High Voltage Power Supply (RF)" is said to be designed for extra-stable well-filtered

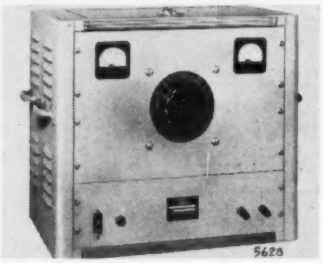


and uniform operation. Voltage range 100 to 5000 vdc; current output 8 ma at 5000 v; output polarity either positive or negative, switch-controlled on front panel; regulation 0.5% or better, no-load to full-load and with line voltage variation from 105 to 130; stability 0.25%; ripple 0.05%; response time better than 0.005 sec from 1 kv to 5 kv.—*Neutronic Associates, 87-16 116th St., Richmond Hill, N. Y.*

For more information circle **314** on inquiry card.

Ten-amp Supply

New "Model GF" is a filtered dc power supply for continuously variable 0-125 v at all loads up to 10 amp.

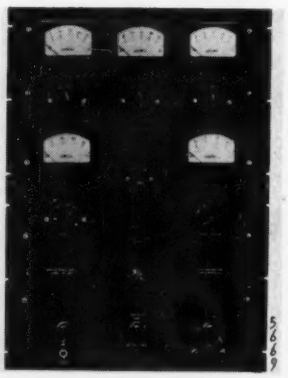


Intermittent loads up to 20 amp can be obtained. Ac hum or ripple is less than 1% at 10 amp. Forced air cooling increases safety, gives longer rectifier life and greater current-carrying capacity. Certified performance charts are furnished.—*Electro Products Labs, 4501 Ravenswood Ave., Chicago 40, Ill.*

For more information circle **316** on inquiry card.

"Zero-lag" Supplies

New high-current regulated supplies, with unusual characteristic of zero recovery time from a line or load



transient, are designed around a fast-response thyratron rectifier, a "stiff" filter, and a large-output storage capacitance. Thirty stock models available; photo shows "Model Z-33," 16-40 v, 0-30 amp.—*NJE Corp., 345 Carnegie Ave., Kenilworth, N. J.*

For more information circle **317** on inquiry card.

ELECTRICAL COMPONENTS

Junction Transistor

New "2N107" *pnp* audio transistor is designed to meet demands of radio amateurs, hobbyists and experimenters for a stable, inexpensive transistor. (Suggested distributor price of "well below two dollars" is said to make it "the least expensive of any transistor currently available.") It has the same physical appearance and dimensional specifications as USAF "2N43a" transistor; all-metal case; hermetically sealed; 38 db power gain in a typical common emitter circuit; maximum frequency cutoff 2.5 Mc with design center at 1.0 Mc; alpha design center 0.95; maximum collector voltage –12; maximum junction temperature specified at 60°C; capable of dissipating 50 mw in 25°C free air.—*General Electric Co., Electronics Park, Syracuse, N. Y.*

For more information circle **318** on inquiry card.

High-speed Transistors

Four new types of germanium *n-p-n* transistors are especially designed for general purpose switching and computer applications. Approved RETMA designations for new high-speed units are 2N124, 2N125, 2N126, and 2N127. With parameter tolerances closely held, new switching transistors feature a beta spread of two to one. (Beta values for individual types are 12 to 24, 24 to 48, 48 to 100, and 100 to 200.) Rise time in a typical circuit is 0.15 usec; typical cutoff time is 3.5 usec. Quality control during manufacture and rigid testing obviate need for additional selection or testing for specific applications.—*Texas Instruments Inc., 6000 Lemmon Ave., Dallas 9, Texas.*

For more information circle **319** on inquiry card.

Output Transformers

New "HS-181 and HS-186" and "S-142 and S-146" hi-fidelity output transformers with screen taps in primary are said to provide extended range and increased power for more modern amplifier circuits. — *Triad Transformer Corp., 4055 Redwood Ave., Venice, Calif.*

For more information circle **320** on inquiry card.

All-magnetic Trigger Generator

New "MP 414-A" all-magnetic trigger generator weighs 14 oz; triggers hydrogen thyratrons by using saturable reactors instead of electron tubes;

digital data recording systems

TEMPERATURE

POSITION

PRESSURE

FORCE

WEIGHT

VOLTAGE

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- WEIGHT DISPLAY AND RECORDING
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- ENGINE TEST FACILITIES

*NAMES ON REQUEST

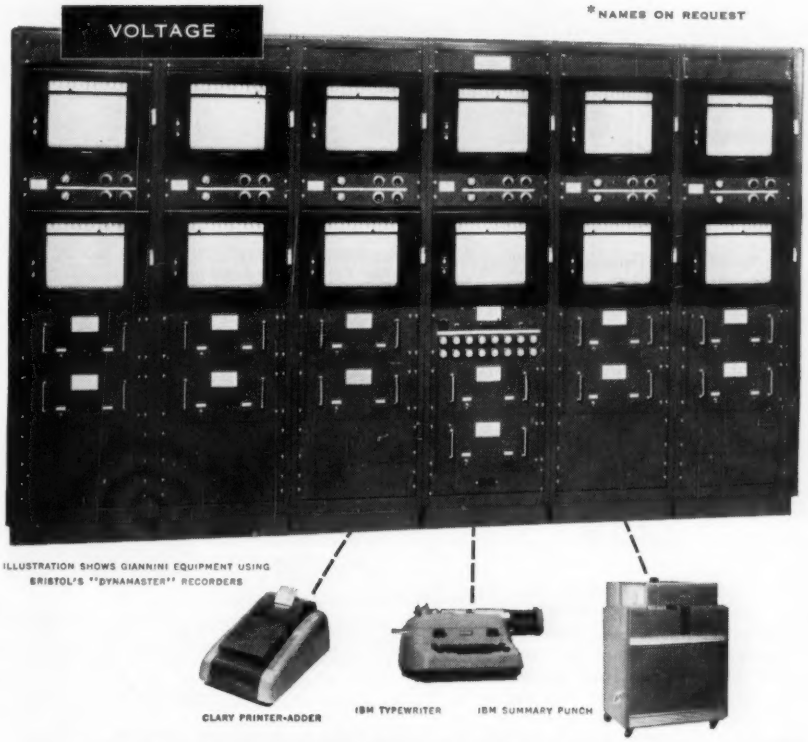

ILLUSTRATION SHOWS GIANNINI EQUIPMENT USING BRISTOL'S "DYNAMASTER" RECORDERS

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IBM TYPEWRITER

IBM SUMMARY PUNCH

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For more information circle **93** on inquiry card.

YANKEE INSTRUMENT FAIR & SYMPOSIUM

The Time: January 10 & 11, 1956
10:00 AM until 10:00 PM
The Place: Sherry Biltmore Hotel, Boston, Mass.
The Sponsor: Instrument Society of America—Boston Section Inc.

The Instrument Fair

Many exhibitors will demonstrate hundreds of new or improved instruments and instrument accessories, many with live demonstrations, for measurement, and control in industry, pilot plant and laboratory.

The Symposium

Concurrently with the FAIR two full days will be devoted to talks and discussions on subjects of instrument interest. Eminent authorities will describe the latest techniques and methods of analysis, measurement and control both in the laboratory, and in the plant and field.

New Englanders & Northeasterners

who were unable to attend the great National ISA Exhibit on the West Coast this fall will find in miniature the opportunity to see the same exhibits and equipment shown in Los Angeles.

FOR FURTHER INFORMATION—CLIP AND MAIL IN THIS COUPON

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c/o ISA-Boston Section Inc.
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My name is: .....

My position is: .....

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For more information circle **94** on inquiry card.

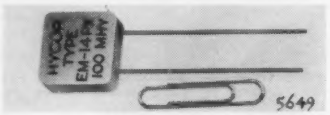
NEW INSTRUMENTS

is a capacitor-type pulser in which electric energy is stored through acresonant charging; replaces about four electron tubes; has applications in commercial radar, lab testing, digital and other computers, etc.—*Magnetic Research Corporation, 200-202 Center Street, El Segundo, Calif.*

For more information circle **321** on inquiry card.

Miniature Inductors

New "EM-14PX," latest "Postage Stamp" toroid coil series, was designed specifically for use in printed circuitry; comprises a subminiature molybdenum Permalloy toroid core

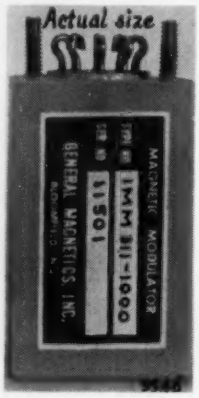


with a winding having a residual hole as small as 1/16" dia; is available in any inductance up to 1 Hy. Useful frequency range 1500 cps to 150 kc, depending on inductance value.—*Hycor Company, Inc., 11423 Vanowen St., North Hollywood, Calif.*

For more information circle **322** on inquiry card.

Magnetic Modulator

New "Mag Mod Type 311-1000," said to be "an absolute substitute for the certain-to-fail mechanical chopper in all automatic control circuits," can be designed for operation on any excitation frequency from 10 cps to several hundred thousand cps. Among features: Clean output fundamental-frequency sine wave of reversing phase and amplitude, fast response time; extremely low hysteresis; meets MIL-T-27.—*General Magnetics, Inc., 135 Bloomfield Ave., Bloomfield, N. J.*



For more information circle **323** on inquiry card.

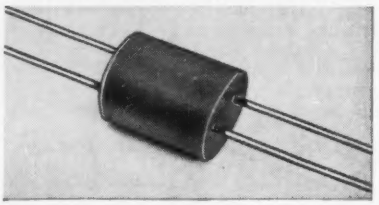
Power Pulse Transformer

New "D211C4B" extra heavy duty pulse transformer for high power applications will handle 15,000 v on primary, delivering 15,000 v at 125 amp from its secondary; is designed to operate with pulse widths of 20 usec; rise-time less than 1 usec; total maximum variation of output pulse from nominal peak value less than 5%. Weight 45 lbs.—*Fisher Engineering, Inc., Huntington, Indiana.*

For more information circle **324** on inquiry card.

Thermally-similar Resistor Assembly

New assembly represents a new method of encapsulating two precision deposited carbon resistors, with nearly identical temperature coeffi-



cients, in a single enclosure in order to provide highly similar thermal conditions within the capsule as ambient temperatures vary. It also increases reliability of individual units when used under extreme humidity, vibration and altitude conditions.—*Clarostat Mfg. Co., Dover, N. H.*, ask for Form No. 754288.

For more information circle **325** on inquiry card.

Ceramic-case Capacitors

New "Pacer" hermetically-sealed "Vitamin Q" impregnated capacitors for operation at temperatures up to

125°C feature use of a ceramic shell instead of a metal one, minimizing capacitance between capacitor section and ground; also providing excellent resistance to effects of humidity and temperature, and extreme stability under all operating conditions.—*Sprague Electric Co., 343 Marshall St., North Adams, Mass.*

For more information circle **326** on inquiry card.

ELECTROMECHANICAL COMPONENTS

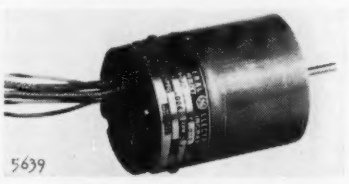
150°C Size 15 Servomotor

New "Series 2287" 400-cps size 15 servomotor which also meets Mark 7 specifications features continuous operating temperatures up to an unprecedented 150°C. Extremely small air gap results in top performance for high torque-to-inertia ratio. Dimensions 1.437" OD x 1.640" L. Weight 8 oz. Minimum stall torque 1.45 oz-in; no-load speed 4800 rpm minimum; power input at stall 12.2 watts total. Can also be wound for 60-cps operation, in which case no load speed minimum is 3200 rpm.—*John Oster Mfg. Co., 1 Main St., Racine, Wis.*

For more information circle **327** on inquiry card.

Aircraft Servomotor

New "5BBY 13 DJ 7" miniature d-c servomotor can withstand a high potential of 150 v and respond to field



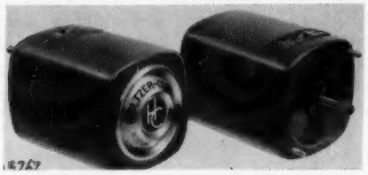
currents of 7.5 ma; operates equally well at sea level or at 50,000 ft and within temperature limits of −65 to 165°F; weighs less than 8 oz; draws

maximum armature current of 0.8 amp from a 28-v line; is rated at 0.002 hp at 6500 rpm and can be geared to speeds as low as 130 rpm. —*General Electric Co., Schenectady 5, N. Y.*

For more information circle **328** on inquiry card.

Instrumentation Motors

New subfractional motor in a 3" diam frame rounds out maker's line of subfractional motors for instru-



ment, recording unit and office appliance applications. Most of new units will be of single-value capacitor type. Efficiencies of various ratings run over 30%—high for motors of this size—whence low temperature rise.—*Holtzer-Cabot Motor Div., Natl Pneumatic Tool Co., 125 Amory St., Boston, Mass.*

For more information circle **329** on inquiry card.

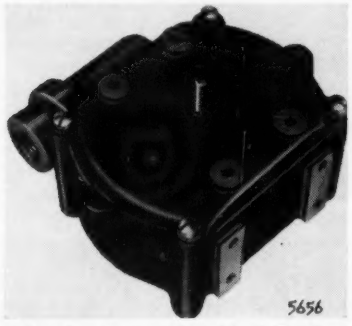
Aircraft Alternator

New 400-cps 12,000-rpm alternator for application on guided missiles and aircraft is designed to meet extreme environmental requirements for short durations; can be driven by a wide variety of prime movers; weighs less than 15 lb; can be rated as high as 2000 va at unity power factor. It is a 3-phase 115-v wye-connected unit.—*General Electric Co., Schenectady 5, N. Y.*

For more information circle **330** on inquiry card.

A-c Rotary Solenoids

New rotary solenoids are said to "incorporate many features that have not been previously available in con-



ventional rotary solenoids." Designed for ac use, units can be operated by standard voltages without use of rectifiers; eight basic sizes; wide range of torque values to 62.5 lb-in at maximum stroke on continuous duty models (intermittent duty models for higher torque values).—*Leetronics, Div. Lee Spring Co., Inc., 30 Main St., Brooklyn, N. Y.*

For more information circle **331** on inquiry card.

Rectified Relays

New relays incorporating full-wave rectifiers are said to provide increased operating reliability throughout wide range from 25 to 400 cps. Among claimed advantages over convention ac operation: higher oper-

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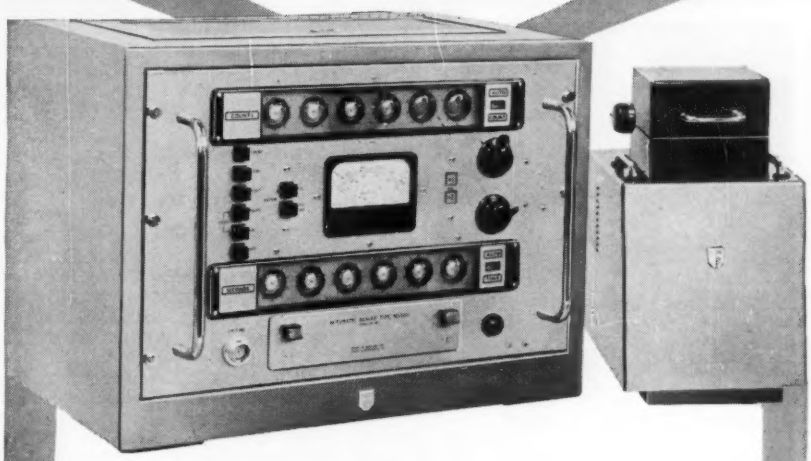

The simplicity and accuracy of Dekatron counting and timing circuits make the **Ekco Model N-530A** Automatic Scaler the most outstanding and most versatile instrument of its kind. This scaler will time a pre-determined count, count for a pre-determined time, or can be manually operated.

FEATURES:

- Preset/elapsed time interval—100-100,000 seconds in 10ths
- Preset/elapsed count interval—100-1,000,000 counts
- Maximum counting rate—60,000 counts/second
- Maximum stopping time—2 milliseconds
- Six electronic decades
- Dekatron direct-reading counting and timing tubes
- Pulse height discriminator permits use with G-M, scintillation, flow or proportional counters—variable 5-50 volt acceptance level

SPECIFICATIONS:

- Input sensitivity—negative 0.1 volt and positive 5 volts
- Input resolution time—5 microseconds, low coincidence loss
- Power Requirements—110-250v, 50/60 cycles, 130 watts
- Dual-range Power Supply—250-1000 and 500-2000 volts
  Stability — ± 0.5% for variations up to ± 10%
  Ripple—less than 5 mv. rms peak

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For more information circle **95** on inquiry card.

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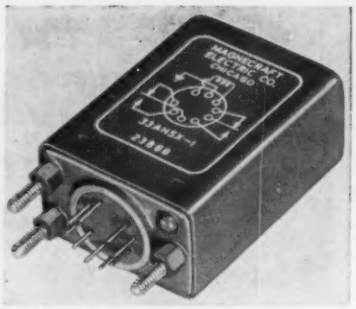
Ford Instrument's standard components

For more information circle **96** on inquiry card.

NEW INSTRUMENTS



ating sensitivity, higher contact pressures, greater resistance to vibration, freedom from ac hum and, in many cases, reduced size.—*Magnecraft Electric Co., 3350 L W. Grand Ave., Chicago 51, Ill.*

For more information circle **332** on inquiry card.

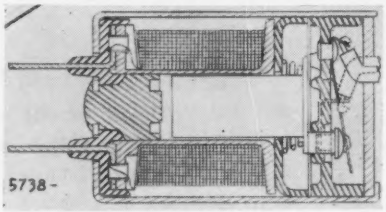
2-amp Relay

New "EB-06 Semi-Sensitive Relay" is a sealed d-c relay with contact rating of 2 amp resistive at 24 vdc or 115 vac 60 to 400 cps. With normal adjustment, it will stand vibration of 10 *G* @ 10 to 1200 cps, temperature from −65 to 125°C, reliability tests MIL-R-5757B. Operating power 100 milliwatts per pole normal (can be adjusted down to 25 mw/p).—*Hufco Industries, Dept. R, 2815 W. Olive Ave., Burbank, Calif.*

For more information circle **333** on inquiry card.

Appliance Relay

New sealed sp-db relay for appliance manufacturers has three contact leads and is equipped with female

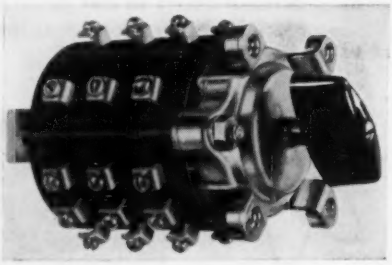


A.M.P. terminals; coil has two male A.M.P. terminals. Unit is available for any voltage from 6 to 115 ac or dc. Contacts are rated up to 8 amp at 115 v non-inductive.—*Guardian Electric Mfg. Co., 1621 W. Walnut St., Chicago 12, Ill.*

For more information circle **334** on inquiry card.

Eight-position Switch

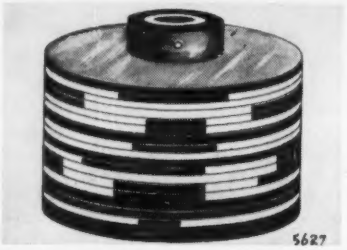
New "JD-JS" rotary switches, for tap, transfer, or selector applications, are rated at 30-amp 230 vac; can be furnished with up to five poles. "JD" type has positive detent action, any number of positions up to 8, with or without OFF position; or switch can have unlimited rotor movement in both directions. "JS" type has snap-action make and break; unlimited rotation in both directions utilizing 8 positions, or action limited to 2,3,4 or 5 positions.—*Electro Switch Corp., Weymouth 88, Mass.*



For more information circle **335** on inquiry card

Switching Commutator

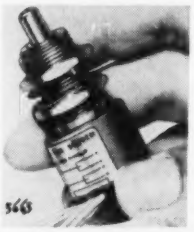
New drum type switching commutator is said to give dependable performance in minimal space. All



switching combinations are attainable. Other applications are frequency multiplication and division.—*Electro-Miniatures Corp., 205 Lafayette St., New York 12, N. Y.*

For more information circle **336** on inquiry card.

Aircraft Sealed Switch

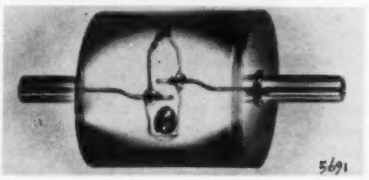


New "1 EN 1-6" sealed cylindrical-shaped switch for use on exposed aircraft applications is said to be "the first of its kind ever built for the aircraft industry"; has two sp-dt switching units sealed within 1-in-diam can-shaped metal housing which is evacuated and filled with inert gas under pressure; features an ice scraper at base of actuator to remove mud or ice which might collect on plunger.—*Micro Switch, Freeport, Illinois.*

For more information circle **337** on inquiry card.

Pulse Switch

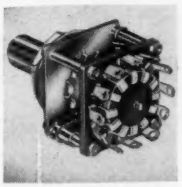
New "Mercury Contact Device" has glass part mounted within a sturdy cartridge (see phantom view) so that



an instantaneous pulse "of many amperes" is caused to flow between the electrodes while mercury drop passes between them. Metallic contact rods protruding axially from ends of insulated cartridge serve as conductors and as means whereby switch is supported between uprights; also make possible mechanical rotation, tilting, etc. Rate of fall of mercury droplet can be influenced by tilting axis of rotation. "Many additional possibilities," including use as a negative speed-governor.—*Tensitron, Inc., Harvard, Mass.*

For more information circle **338** on inquiry card.

Miniature Rotary Switch



New "M-12" miniature twelve-position switch is designed for use in applications requiring up to 3 amps at 115 vac. Up to six decks can be ganged for operation with a single knob. "M-12" is ¾" square, and weighs ½ oz. Switching action can be shorting (make-before-break) or non-shorting (break-before-make), with continuous rotation or movement limited from 2 to 11 positions.—*R-F Electronics, Inc., Div. Electro Switch Corp., Weymouth* 88, *Mass.*

For more information circle **339** on inquiry card.

Overheat-protector Switch

New "Type B9500" thermal switch is a small tubular shaped inherent overheat protector that can be mounted directly in motor windings or small transformer enclosures. Disc type thermal element assures positive snap-acting make and break. Rating 10 amp at 115 vac.—*Spencer Thermostat Div., Metals & Controls Corp., Attleboro, Mass.*

For more information circle **340** on inquiry card.

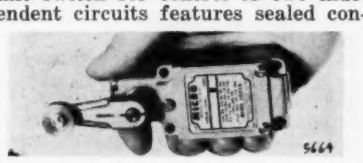
High-speed Rotary Switch

New high-speed rotary synchronous multipole switch commutator is for telemetering, switching radar data presentation, commutating thermocouple signals, etc. A 12,000-rpm 115-v 400-cps single-phase motor drives brush assembly at 10 rps; three sets of carbon-type brushes bear on precious-metal segments to provide BBM operation without riding on filler material, whence extremely low noise and long life. Switch can carry 0.1 mv to 100 v from 3 uamp to 50 ma; has over 500 hours' life; meets MIL-STD-202. Other switch combinations of brushes and speeds available on special order. —*Instrument Development Labs., Inc.*, 163 *Highland Ave., Needham Heights* 94, *Mass.*

For more information circle **341** on inquiry card.

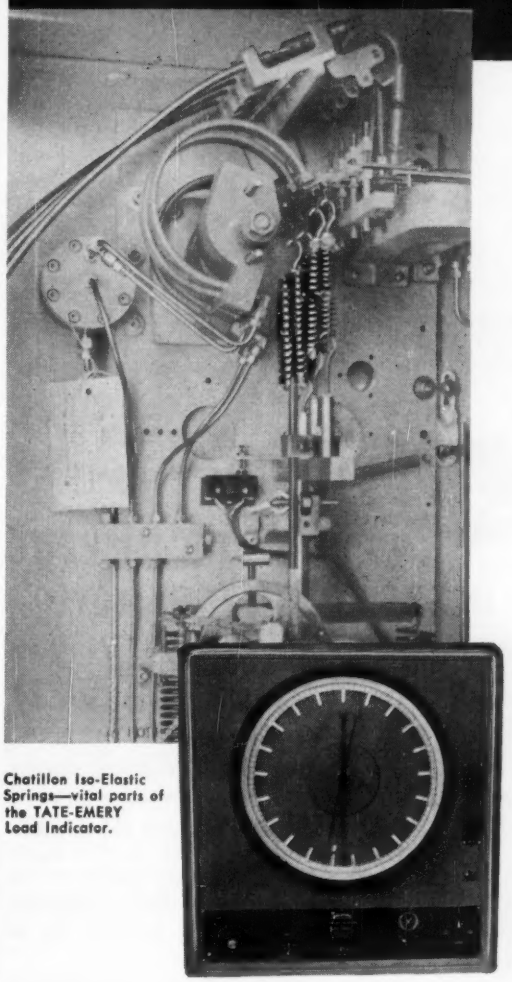
Two-circuit Limit Switch

New "1 LS 1" small-size heavy-duty limit switch for control of two independent circuits features sealed con-



CHATILLON ISO-ELASTIC* Precision Springs

insure force measurement accuracy despite wide temperature variations . . .



Chatillon Iso-Elastic Springs—vital parts of the TATE-EMERY Load Indicator.

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For more information circle **97** on inquiry card.

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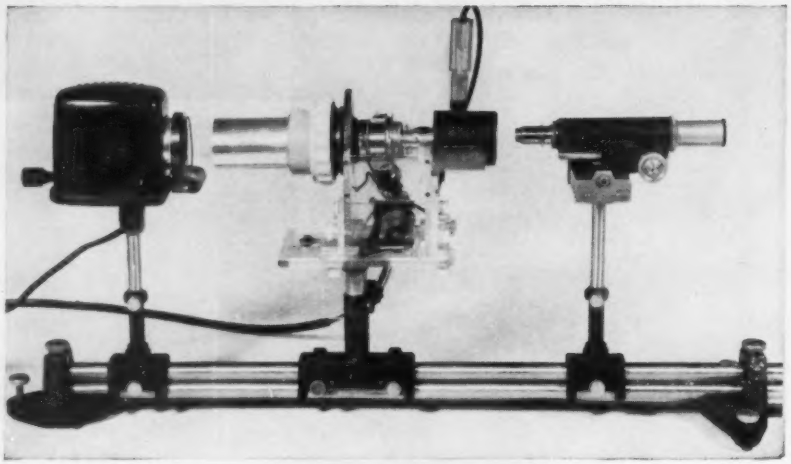

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For more information circle **98** on inquiry card.

struction and high electrical capacity plus adjustability. Roller-arm actuator can be field-adjusted through 360° with positive locking in any position. Actuation can be clockwise, counter-clockwise or in both directions. —*Micro Switch, Freeport, Illinois.*

For more information circle **342** on inquiry card.

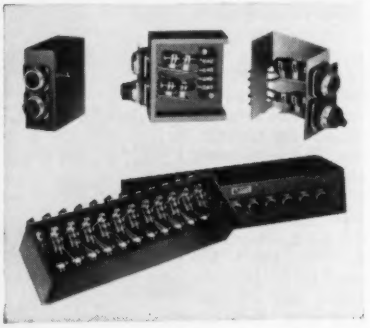
Watertight Switches

New heavy-duty machine-tool switches incorporate a water-tight feature (Nema Types 1-A, 2, 4, and 5); withstand water, dust and oil conditions even under severe operating conditions; made in a variety of styles which include dp-st-db, 3p-db, dp-st-db, neutral-position dt-db-no, and neutral-position dt-db-nc. All models have isolated circuits. Over 150 lever styles.—*The R. B. Denison Mfg. Co., 102 St. Clair Avenue N. W., Cleveland 13, Ohio.*

For more information circle **343** on inquiry card.

Mercury Safety Switches

New line of mercury switches for momentary pushbutton or selector type operation includes fully-enclosed



models in single or multiple units; open bracket types for panelboard applications; and many special combinations and arrangements for specific design problems.—*Industrial Automation Corp., 2415 W. Montrose Ave., Chicago, Ill.*

For more information circle **344** on inquiry card.

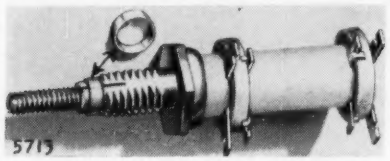
Shielded Coil Forms

Two new shielded coil forms: "LS-10" is ⅝" diam by 15/16" over-all heighth when mounted, including terminals. "LS-11" is 5/16" diam; over-all heighth, when mounted, 17/32". Each mounts by a single mounting stud. Both are highly shock-resistant, with mechanically-enclosed protected coil windings; suitable for IF strips, RF coils, oscillator coils, etc. Available as coil form assemblies, or wound to customer specs.—*Cambridge Thermionic Corp., 445 Concord Ave., Cambridge 38, Mass.*

For more information circle **345** on inquiry card.

Coil-forms Lock

New "Perma-Torq" is a new permanent locking device for maker's standard ceramic coil forms. It is a com-

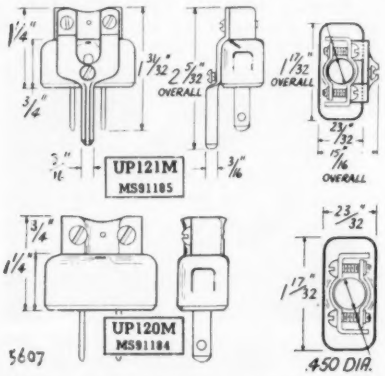


pression spring, made of beryllium copper whose extremely high fatigue resistance provides a permanent and constant torque. It comes factory assembled to mounting studs. Old and new coil form types will mount through the same chassis holes.—*Cambridge Thermionic Corp., 445 Concord Ave., Cambridge 38, Mass.*

For more information circle **346** on inquiry card.

Bladed Power Connectors

New miniature armored connectors meet requirements of recently amended MIL-C-3767 (Amendment #1). Two-bladed version, "UP120M," and

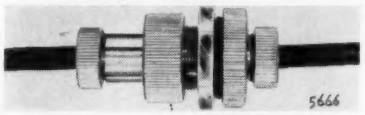


3-bladed "UP121M" conform to new military standard drawings MS 91184 and MS 91185 respectively. Plugs are rated for 125-v 15-amp up to 250-v 10-amp and will accomodate cables from 0.125 in to 0.450 in.—*Automatic and Precision Mfg. Co., 252 Hawthorne Ave., Yonkers, N. Y.*

For more information circle **347** on inquiry card.

Water- and Pressure-proof Connectors

New "PW-51" connectors, available in five sizes with AN-type inserts, are not only waterproof but withstand



pressure in excess of 200 psi. Pressure-proof caps are available to fit both plugs and sockets.—*Midwestern Instruments, 3401 South Harvard, Tulsa, Okla.*

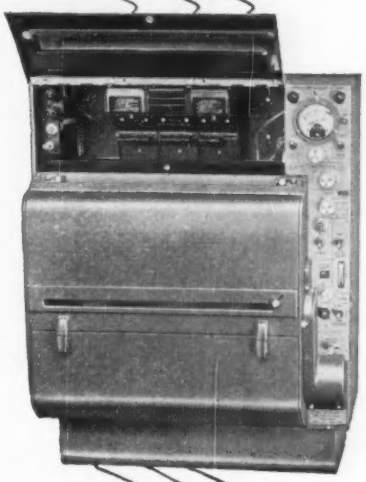
For more information circle **348** on inquiry card.

Push-in Terminals

New "X-2182" push-in insulated terminals utilize properties of teflon as a holding material and as an insulator; permit a press-fit into mounting panels 1/16" to ⅛" thick with secure seating that keeps terminals shake-

MINNEAPOLIS
Honeywell
Heiland OSCILLOGRAPH

Easy access to galvanometer and damping resistor network is provided from the front by means of a hinged cover door.



The new Heiland Series 700C Recording Oscillograph will give consistent, unfailing service, provide a broad range of galvanometer frequencies and sensitivities, a wide selection of record speeds, and as many channels as you need.

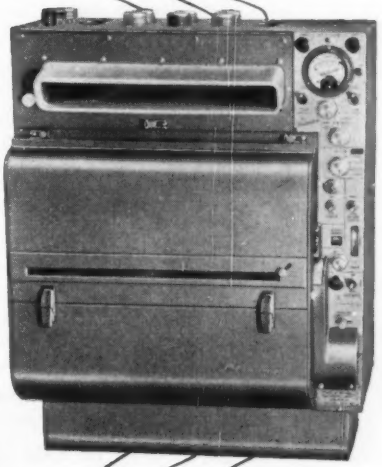
For example, the Model 712-C features a 12-inch record width, with up to 60 channels.

If that's more than you need, the 708-C carries an 8-inch record with up to 36 channels.

ACCESSIBLE
easy to operate . . . . . .

Both models feature record speeds from .03"/sec. through 144"/second. Galvanometers with unequalled sensitivity ratings are available in frequencies up to 5000 cps. Either model may be relay-rack mounted if desired.

Heiland Series 700C Recording Oscillographs will simplify and expand the scope of your dynamic testing.

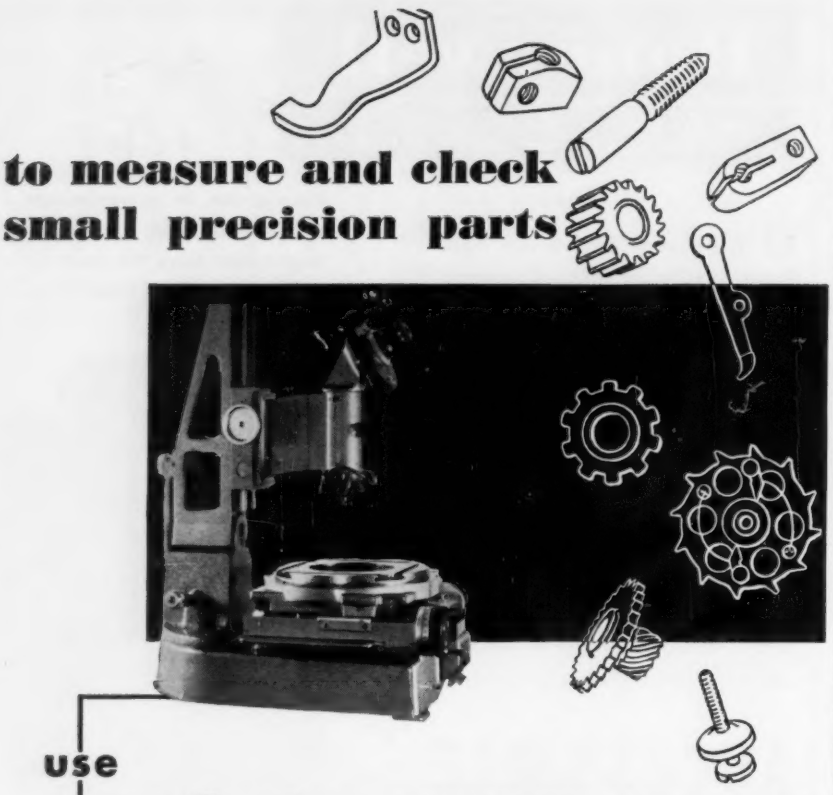


Separate light-tight record drums permit easy daylight loading; access to drive gears permits instant selection of record speed ranges.

Write for Bulletin 700C-A for complete details.

Heiland® H HONEYWELL
A DIVISION OF MINNEAPOLIS-HONEYWELL
130 E. 5th Ave., Denver 3, Colo.

For more information circle **99** on inquiry card.



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Coordinate Range	2"x4"
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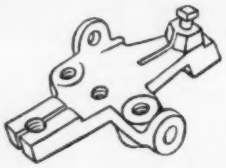
Angular Range	360°
Reading to	1 minute
Magnification	30X
Protractor Range	360°
Reading to	1 minute



the *Gaertner Scientific Corporation*

1211 Wrightwood Avenue, Chicago 14, Illinois

WRITE FOR BULLETIN NO. 147-50

For more information circle **100** on inquiry card.

If the inquiry card in this issue has been used by someone else, use the form below. Insert Inquiry No., sign, and mail to:

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NEW INSTRUMENTS

proof; feature high terminal pull strength in any direction.—*Cambridge Thermionic Corp.*, 445 *Concord Ave., Cambridge* 38, *Mass.*

For more information circle **349** on inquiry card.

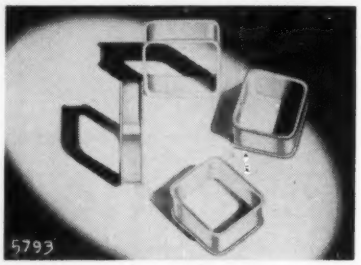
Diode Clip

New spring-loaded diode clip that securely holds fragile diode pig-tail leads from 0.005" to 0.035" diam is made of brass and is finished in 0.0002" bright alloy plate. When mounted it is 11/32" in over-all heighth. Mounting stud is 7/32" long, hexagonal with a 2-56 threaded stud. —*Cambridge Thermionic Corp.*, 445 *Concord Ave., Cambridge* 38, *Mass.*

For more information circle **350** on inquiry card.

Moving-coil Forms

New moving-coil forms for instruments are said to be produced by a new method "which virtually elimi-

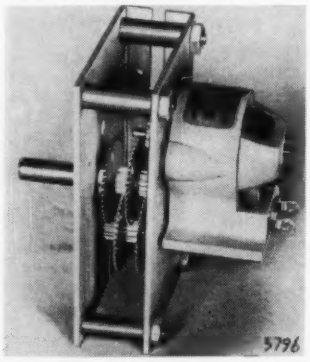


nates cracked corners, incorrect temper and failure to hold tolerances." Forms are available in aluminum alloy (25, 35, and 525) and in copper, with tolerances to 0.001" and walls down to 0.003".—*Uniform Tubes, Inc., Level Rd, Collegeville* 2, *Penna.*

For more information circle **351** on inquiry card.

Gearmotor

New motorized gear train unit will find application where dry cells or other batteries are the power source.



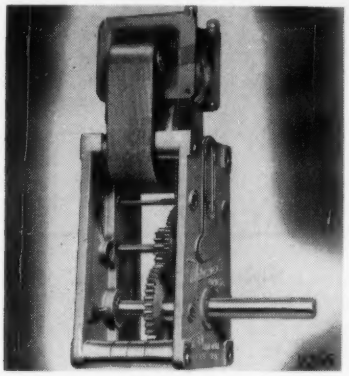
Maker's "Hi-Drive" motor, available in three voltage ranges (1½ to 3, 3 to 6, or 6 to 12) has an Alnico permanent field magnet and a wound 3-pole armature; is reversible. Entire motor and reduction gear unit is only 3⅛" x 3" x 2⅛"; drive shaft extends 11/16". No-load motor speeds 2,000 to 10,000 rpm. Speed can be controlled by a

small rheostat. Ratio being 662 to 1, drive-shaft speed can be varied from 3 to 15 rpm with ample power.—*Wilson's of Cleveland, 425 Lakeside Ave., N. W., Cleveland 13, Ohio.*

For more information circle **352** on inquiry card.

Gearmotor

New "AC Super Gearmotor" has high starting torque characteristics; can be provided to operate on either



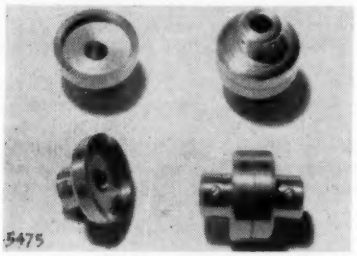
continuous or intermittent duty. Output torque is 120 to 500 oz-in at 10 rpm depending on duty cycle. Output shaft can be geared to 3 rpm and up. Length 5½", width 2-15/32", depth 1-9/16". (With magnetic clutch, depth is 1-11/16"). All motors built to customers' specs.—*Motoresearch Co., 1602 Junction Ave., Racine, Wis.*

For more information circle **353** on inquiry card.

MECHANICAL COMPONENTS

Multi-jaw Couplings

New "Type N4" precision multi-jaw couplings are available in three basic shaft sizes: ⅛, 3/16 & ¼ in

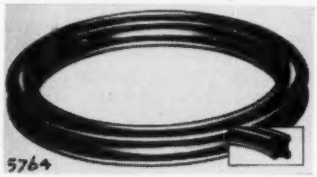


diameters and in combinations of dissimilar shafts; are made of #303 stainless steel; have stainless steel setscrews for holding and sub drill holes for fixed pinning as desired.—*Pic Design Corp., 160 Atlantic Ave., Lynbrook, L. I., N. Y.*

For more information circle **354** on inquiry card.

Vacuum-pump Rings

New "Quad-Rings," injection molded from 366Y compound, were designed to eliminate many faults of



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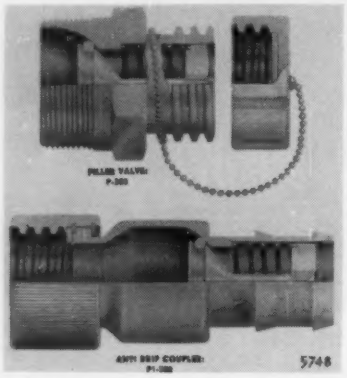
For more information circle **101** on inquiry card.

other seals, such as spiral twist failures, rolling with pulsating pressure, torque leakage at low pressure differentials and mold parting line with consequent flash on sealing edges. Maker claims economy through lower installation cost and ability to perform efficiently without requiring extra-fine metal finish and close tolerances in ring grooves.—*Minnesota Rubber and Gasket Co., 3630 Wooddale Ave., Minneapolis 16, Minn.*

For more information circle **355** on inquiry card.

Coupler for Rapid Transfer of Fluids

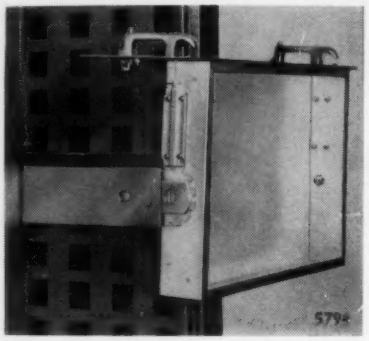
New coupler is designed for safe and rapid transfer of liquids or gases; permits fluid to be transferred and maintained under pressure preventing loss of vapor or tank pressure. Filler valve threaded into tank incorporates a check-valve unit to permit flow into tank and automatically shut off when coupler is disconnected. Coupler unit shown incorporates an anti-drip valve; another is designed to open valve unit in filler valve to permit draining or reverse flow.—*James-Pond-Clark, 2181 E. Foothill Blvd., Pasadena 8, Calif.*



For more information circle **356** on inquiry card.

Chassis Slide

New "Chassis-Trak" is versatile in that a chassis mounted upon it can not only slide out from rack-cabinet to a



locked "out" position, but can be rotated while in this position. Two variants: "Type CTD" has a tilt-lock detent mechanism locking at 30° intervals from minus 90° to plus 120°; "Type CTB" tilts back to plus 120° for underside servicing. "Chassis-Trak" is designed to universal rack standards; both types are available for chassis depths of 14", 16", 18", and 20".—*Ventrak Corp., 11 W. 42 St., New York, N. Y.*

For more information circle **357** on inquiry card.

Light-wall Tubing

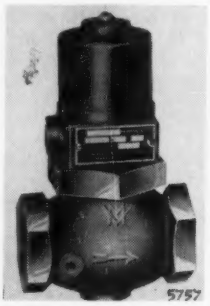
New "Types 304 and 321 Weldrawn" stainless light-wall tubing have production limits expanded to 2-1/16" OD. (Maximum size had been 1⅛" OD.) Tubing is offered in AISI Types 304, 321, and 347 and in Monel metal, in lengths to 28′ maximum.—*Superior Tube Co., 1565 Germantown Ave., Norristown, Pa.*

For more information circle **358** on inquiry card.

VALVES

Solenoid Valve

New "Type G" full-port normally-closed valve does not require back pressure in its operation; will operate

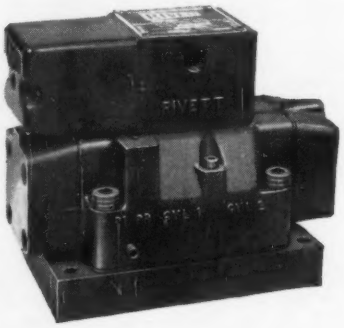


and hold fully open, with low or no flow pressure at all; is also suited for use on vacuum lines as well as in control of liquids in a wide range of viscosities. Temperature limit in latter application is 212°F, static rating is 150 psi.—*Magnatrol Valve Corp., 71 Fifth Ave., Hawthorne, N. J.*

For more information circle **359** on inquiry card.

Solenoid Valve

New "Model 6615" single-solenoid pilot-operated hydraulic valve for automatic control of hydraulic circuits



is conservatively designed for full 3000 psi; is available in ½", ¾", 1", 1¼" and 1½" sizes; meets all J.I.C. requirements and features full capacity rated at 3.6 gpm at 15 fps.—*Rivett Lathe & Grinder, Inc., Brighton 35, Boston, Mass.*

For more information circle **360** on inquiry card.

New low-cost
DIGITAL VOLTMETER

SADIC DIGITAL VOLTMETER (TYPE 33-110) is CEC's newest unit for low-voltage analog-to-digital conversion. It offers true economy plus high accuracy. Output includes illuminated numerical display (above) and decimal-coded contact closures. Suitable for bench use or rack mounting (two units fit side by side in 19" rack) the 33-110 is useful for both laboratory indication and as a building block for automatic data-processing systems.

SPECIFICATIONS

...digital range ..... 000 to 999 (1000 steps)
...accuracy .....1/10th % of full scale
...sensitivity .....10 millivolts provides full-scale output
...balance time .....0.8 second, max.
...power source .....105-115 volts a-c

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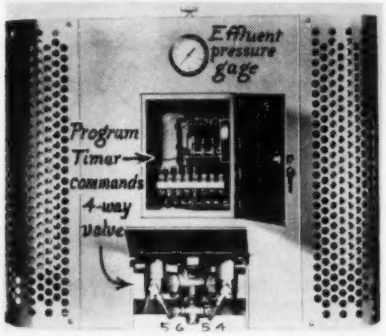
For more information circle **102** on inquiry card.

MISCELLANEOUS

Dynamic Dehumidifier

New "Midget Dryer," for drying small volumes of compressed gases to sub-zero dewpoints, a completely



new solid desiccant type dynamic dehumidifier. Three sizes, all completely automatic, electrically regenerated, wall or bench mounting.—*Industrol Corp., Roselle Park, N. J.*

For more information circle **361** on inquiry card.

Combination Fire and Burglar Alarms

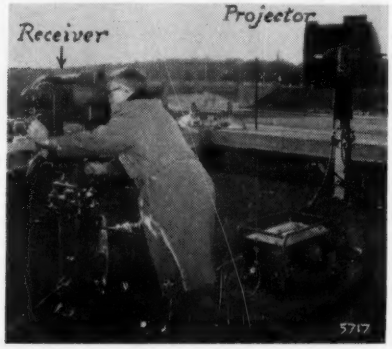
New combination fire and burglar alarms are offered in 3 unitized models comprising a master audible alarm

signal station, actuated from any number of thermostatic fire-detector units.—*Industrial Automation Corp., 2415 W. Montrose Ave., Chicago, Ill.*

For more information circle **362** on inquiry card.

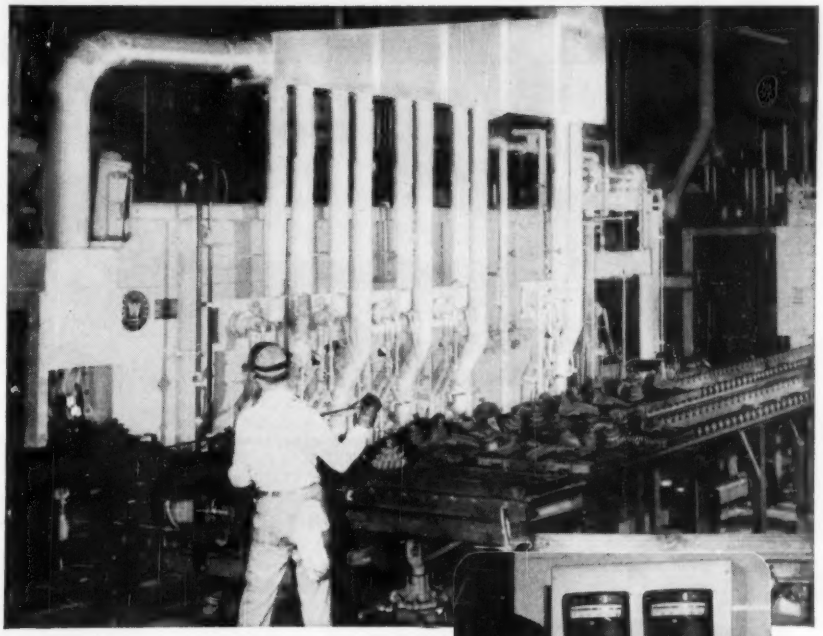
Night Viewer

New "Night Viewer" permits vision in complete darkness for distances up to more than two miles. Normal applications: navigation, police work, manufacture of photosensitive materials, etc. It comprises an infrared radiator which projects



BARBER COLMAN

Wheelco Integral Furnace Control



for "packaged efficiency" in controlling heat!

Wheelco Control Centers offer a modern, integrated, packaged system which performs efficiently because all control components are designed and manufactured to function together. The furnace shown above is equipped with Control Centers utilizing new Wheelco Model 405 Capacitrols for improved proportioning control. This system keeps furnace temperatures precisely at the control point, reduces fuel costs, and reduces maintenance caused by start-stop, off-on heating.

Control Centers are the most effective way to organize control equipment for improved performance, greater safety, and permit flexible rearrangement to meet constantly changing control needs. Plug-in instruments and control circuits require less space, and reduce costs by saving wiring and rewiring time. All sizes and types of control units are interchangeable without rearrangement of the entire control assembly. At the left, we show Barber-Colman fuel valve actuators mounted on an industrial furnace. These are only a single item from the complete Wheelco line which includes: controllers; control centers; recorders; power units; thermocouples; and combustion safeguards. Your Wheelco field engineer will be glad to help in designing and specifying any type of control system you might require. Call him today!

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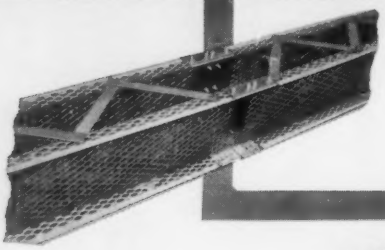
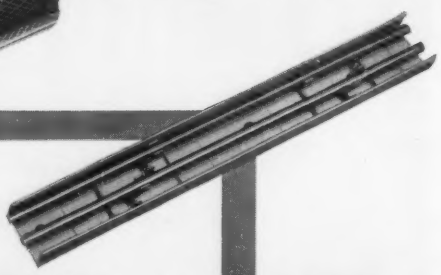
For more information circle **103** on inquiry card.

INSTROF

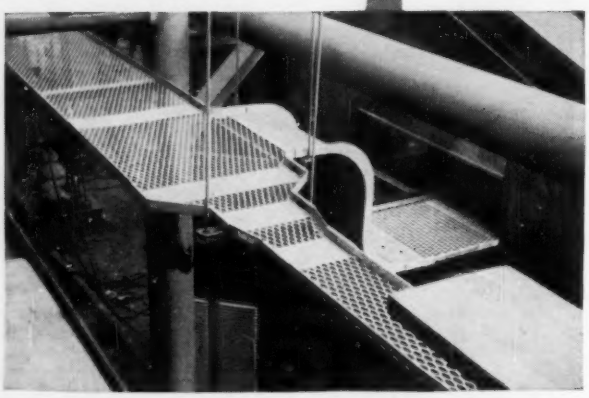
for the support of instrument tubing



BOX GIRDER—for long unsupported span lengths.



TUBE RACE—for branch run.



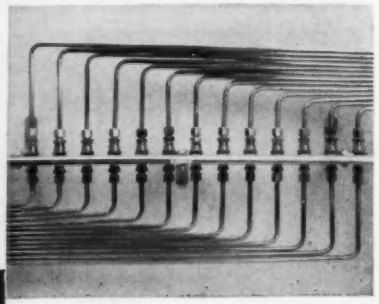
The Instrof System installed in a large South-West Coast Chemical Plant. All fittings are stock items which were rapidly assembled on the job. System is ready for placement of tubing.

Instrof is a system of prefabricated metal trough specifically designed to give continuous support and protection to instrument tubing. It is the most versatile system of its kind on the market today, and can be readily assembled at the job site in an extremely short time. Once installed, it requires no maintenance.

Instrof is available in widths of 3", 6", 9", 12", 18", and 24" with a complete range of fittings for all widths. These fittings enable the system to follow walls, change direction and elevation, and to change from one width to another—in short, to conform to any plant layout.

For further information on how the Instrof System can help solve your tubing problems, write today for the new Instrof Catalog. Ask for Bulletin I-11.

The Instrof Bulkhead Bar is a light section of channel with ¼" brass couplings mounted on 1½" center. It can be used wherever straight or angle tube terminal connections are required, such as junction boxes, panel boards, etc. It is especially adaptable to mounting on Instrof sections. The standard bar contains 40 ¼" brass couplings and is five feet long. Other sizes can be manufactured to customer's specifications.



INSTROF

INCORPORATED

4923 PENTRIDGE ST.
PHILADELPHIA 43, PA.

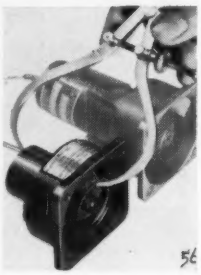
For more information circle **104** on inquiry card.

NEW INSTRUMENTS

an invisible beam upon a selected object or location, and a receiver that converts the reflected infrared image to rays visible in viewer. These two units are synchronized for simultaneous focusing upon an object. Equipment can be matched with an industrial camera to permit centralized monitoring of a series of viewers.—*Curtiss-Wright Corp., Wood-Ridge, N. J.*

For more information circle **363** on inquiry card.

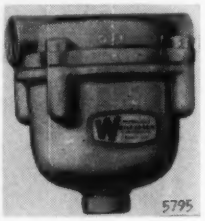
Miniature Axial Blower



New miniature axial blowers for either ac or dc are announced. Ac units are a combination of maker's "Type SC" 400-or 60-cps motor and a die-cast aluminum fan in a die-cast aluminum housing. Dc unit makes use of maker's "Type SS" motor, furnished with any standard winding. Housing on both ac and dc models provides environmental protection to military specs.—*Globe Industries, Inc.*, 1784 *Stanley Ave., Dayton 4, Ohio.*

For more information circle **364** on inquiry card.

Moisture-discharge Separators



New "Series 125" moisture-discharging separators for compressed air equipment operating between 10 and 250 psig do not increase air requirements and will not flutter. Action is fully automatic in separation and discharge of free oil, water and non-gaseous contaminants as air is used. Four models are offered, serving ¼" to ½" lines.—*Wilkerson Corp.*, 1667 *W. Girard Ave., Englewood, Colo.*

For more information circle **365** on inquiry card.

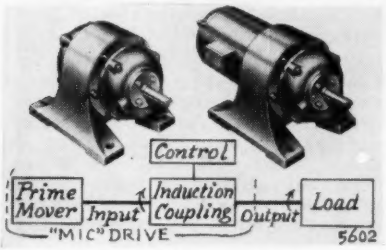
Numbers and Letters

New individual self-sticking numbers and letters, in six sizes from ½" to 5" high, mounted on handy dispenser cards, are available in two colors: black on white and black on yellow; are made of impregnated cotton cloth with a temperature-resistant pressure-sensitive adhesive. They come mounted on handy dispenser cards which protect the adhesive until used.—*W. H. Brady Co., 727 W. Glendale Avenue, Milwaukee 12, Wisconsin.*

For more information circle **366** on inquiry card.

Motor Speed Control

New "Motor Induction Coupling" (abbrev "MIC" Drive) provides stepless variable speeds over ranges from



2-to-1 ratio to 34-to-1, with constant torque output. Features: automatic speed regulation; fast response. Motor sizes ¾ hp @ 3400 rpm to 75 hp @ 1700 rpm.—*American Electronics Inc., 2112 Chico Ave., El Monte, Calif.*

For more information circle **367** on inquiry card.

Plastic-foam Materials

New "Eccofoam Hi K" plastic foam materials combine high dielectric constant and low weight, for microwave lens systems, antennas, radome cores, etc. New material has an extremely low dissipation factor and is usable from −65°F to 275°F; is presently available as sheet stock (easily machined) or as custom-molded shapes of exact dimension.—*Emerson & Cuming, Inc., 869 Washington St., Canton, Mass.*

For more information circle **368** on inquiry card.

Copying Machine

New "Copease," said to be "the world's most successful office copying machine," produces, in less than

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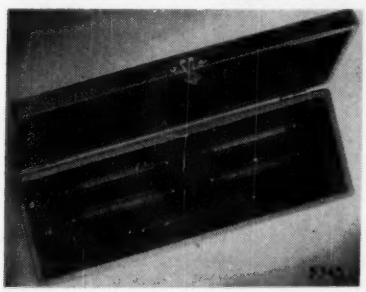
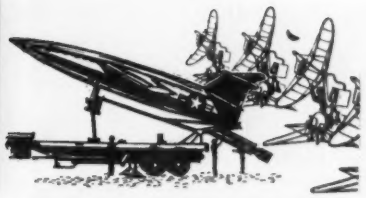
Quartz Spring Kit

New engineering kit contains five precision helical springs fabricated of fused quartz to thicknesses finer than a human hair. Kit provides immediate selection of varying loads and sensitivities: load maxima from 5 g



they shall not pass!



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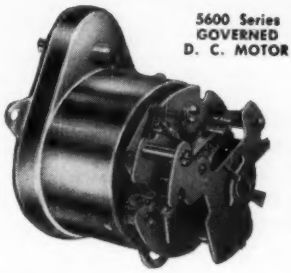

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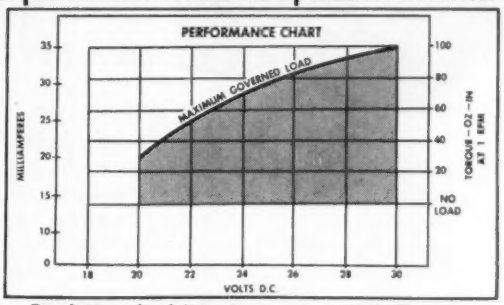

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4. Tolerance on escapement rate:
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   (b) ± 0.3% under condition 2
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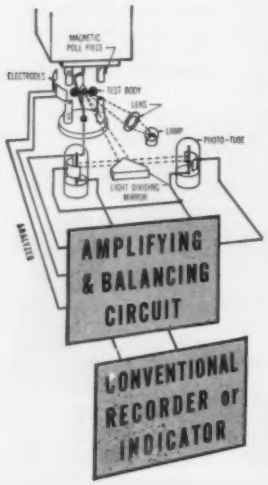

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to 50 mg, with maximum extension of 5 cm throughout. All five units are maker's stock items available in production quantities.—*Houston Technical Labs., 2424 Branard, Houston, Tex.*

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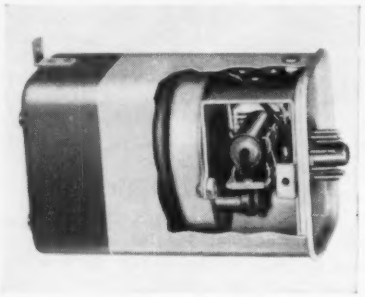
Flasher-type Timers

New cam-actuated motor-driven flasher units, utilizing mercury-to-mercury contacts for exceptionally



high current interrupting capacities, are available from 6 v to 250 v ac or dc. Any rate of interrupting or coded cycles can be obtained in standard unitized plug-in type housings suitable for all-purpose or for hazardous and corrosive applications.—*Industrial Automation Corp., 2415 W. Montrose Ave., Chicago, Ill.*

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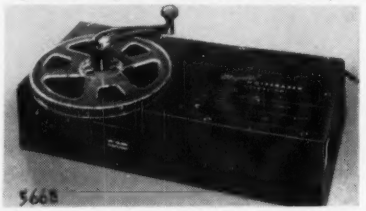
Mag-tape Restorer

New "Noiseraser" removes all saturation signals from entire reels of magnetic taps in a few seconds, re-



stores tape to a completely erased condition; also conditions new tape and increases dynamic range.—*Minnesota Electronics Corp., Burbank, Calif.*

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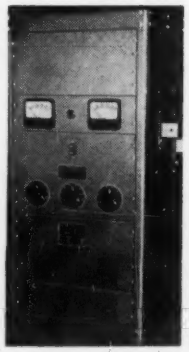
Germanium Rectifiers



New germanium rectifiers, available in several models in various ampere outputs to meet most requirements, are said to "offer users greater efficiency over other types of conversion equipment . . . maintenance costs are practically nil compared to other large dc power supplies."—*Walker Div., Norma-Hoffman Bearings Corp., Stamford, Conn.*

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Burning-index Meter

New "Burning Index Meter" permits computing the variety of natural conditions that may result in disastrous forest fires. It allows all the variables of weather, humidity, etc., to be coordinated into a single figure that accurately estimates the mathematical possibilities for a fire in any section of the national forests. It will help forest rangers to determine when and where to take additional preventive measures and to assemble equipment for fast action—*Sillcocks-Miller Co.*, 10 *W. Parker Ave., Maplewood, N. J.*

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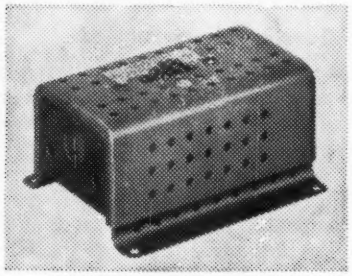
Motor-speed Controller

New "Varitrol Voltage Variator" is a small (3x4x6") low-cost reactor for ac motor speed control and other voltage-reducing uses. Available ca-



pacities: 0.5 to 7.0 amp, 115/220-v line, 20 to 40 v drop.—*Killeen & Son Production Eng'g Co.*, 340 *W. Compton Blvd., Gardena, Calif.*

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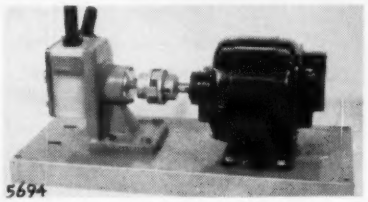
Pumps for Corrosive and Abrasive Service

New "XB Series" (External-Bearing) rotary type pumps combine basic self-priming no-stuffing-box no-shaft-



seal features of maker's "Flex-i-liner" pump with a design that permanently protects all bearings from fumes or chemical attack. Available in capacities from fractional to 5 gpm, with 0-50-psi discharge pressures.—*Vanton Pump & Equipment Corp.*, 201 *Sweetland Ave., Hillside, N. J.*

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Screen Process Ink

New "P.C. Black" free-flowing screen process ink is designed specifically to meet requirements of printed circuitry. Its opacity allows it to lay an unbroken resist line of hairline accuracy without blobing or breaking the circuit. Two types: one which can be air-dried for normal production, another can be heat-dried for accelerated volume. Although black has highest visibility factor, "P.C." (printed circuit) line is available in any standard color.—*Naz-Dar Co.*, 461 *Milwaukee Ave., Chicago* 10, *Ill.*

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Laminating Resin

New "Ecco L65" has outstanding electrical properties: it produces low-loss low-dielectric-constant laminates for use in radomes, antennas and printed circuits; is easy to use with either fiber glass cloth or mat. Resulting laminates retain excellent properties to 300°F.—*Emerson & Cuming, Inc.*, 869 *Washington St., Canton, Mass.*

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Voltage-frequency Control for M-G Sets

New "VF Controls" are "packages" for precise regulation of both voltage and frequency of motor-alternator sets

and inverters: "VF-60" for 60-cps outputs and "VF-400" for 400-cps permit conversion from any dc source voltage to any ac output voltage within ratings of controlled machine.—*Electric Regulator Corp.*, 314 *Pearl St., Norwalk, Conn.*

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Statement of the Ownership, Management, Circulation, Required by the Act of Congress of August 24, 1912 as amended by the Acts of March 3, 1933 and July 2, 1946 (Title 39, United States Code, Section 233) of

Instruments and Automation

published monthly at Pontiac, Illinois, for October 1, 1955.

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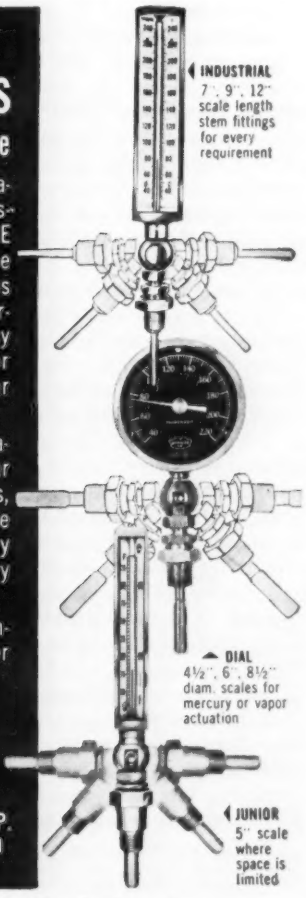
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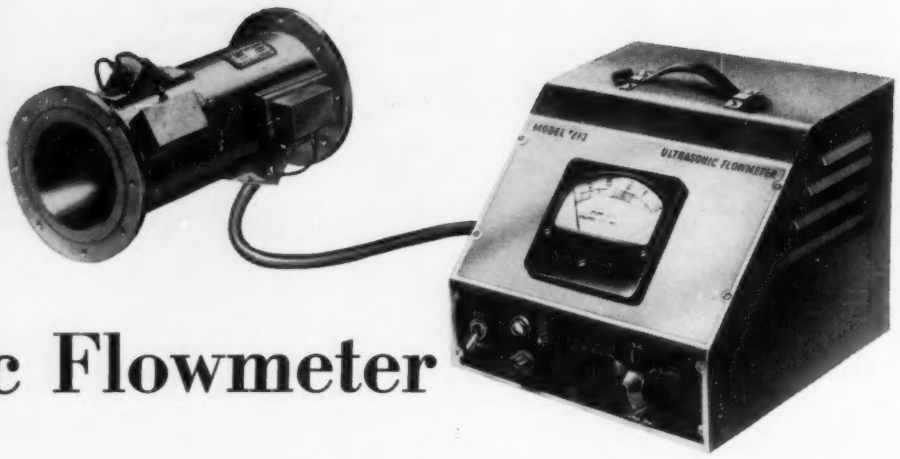
Fig. 1. Ultrasonic flowmeter measures volumetric and mass flow rates by use of 10-Mc quartz crystals, four of which are arranged as in Fig. 2 for flow rate measurement, and one for density measurement. Rangeability is 20:1; accuracy is better than 2% of full scale; linearity is better than 1% of full scale. Fluid density range of 2.5/1 can be accommodated.



Ultrasonic Flowmeter

Principle for Flow Rate Measurement

Fig. 2 shows a section of pipe with four transducers (piezoelectric or magnetostrictive) for the generation of ultrasonic pressure waves in a flowing fluid.

Transducer 1 emits a beam of energy (directed at receiving transducer 2) whose velocity of propagation in the pipe fluid is v. The time of transmission through the distance d when fluid is still is $T = d/v$. When the fluid is in motion with velocity x, the component in the direction of transmission is $x \cos \theta$, and the time of transmission between transducers is then $T_1 = d/(v + x \cos \theta)$. Similarly, for transmission from transducer 3 to 4, transit time $T_2 = d/(v - x \cos \theta)$ because the velocity component opposes the direction of propagation.

It is desired to generate two oscillations whose periods are given by T_1 and T_2. Fig. 3 shows one simple way of accomplishing this. The excitation is delivered from a carrier generator to the transmitting crystal through a modulator. When the acoustic vibrations reach the receiving transducer (after a period determined by the transit time), they are amplified and detected. The detected signal is then applied to the modulator to turn the modulator off. A quiet period ensues, *equal to the transit time*, until the receiver ceases to receive vibrations. The modulator then proceeds to deliver excitation to the transmitting transducer for a time also equal to the transit time, and the cycle is repeated.

When two such oscillating loops are applied to the transducers shown in Fig. 2, two signals are available whose frequencies are the reciprocals of twice the transit time. The beat, or difference frequency is $f_1 - f_2 = x \cos \theta/d$. Note that the only variable is x, the fluid velocity to be determined. The velocity of propagation of the ultrasonic energy (v) in the fluid does not affect determination of fluid velocity.

In an early phase of the development it was decided to use a carrier frequency of 10 Mc (to obtain high directivity with low insertion loss). For a four-inch line and 45-degree-inclination of transducers, the transducer spacing is about 6 inches. This is equivalent to a time delay (time for signal to traverse the 6 inches) of about 100 microseconds, which causes each of two oscillators to run at about 5000 cps. At the maximum flow rate, the beat frequency between the oscillators is about 50 cps. Therefore, the flow rate measurement is based on the determination of a small difference between two large numbers. The basic problem is how close a zero beat can be maintained between the two loops with the fluid at rest.

Abstracted from Preprint 55-16-3, presented at ISA National Conference, Los Angeles, Sept. 12-16, 1955. Copies available from ISA, 1319 Allegheny Ave., Pittsburgh 33, Pa.

Principle for Density Measurement

Consider a crystal in contact with the fluid, and excited by a constant-voltage source at its resonant frequency. The magnitude of the output voltage will be $K\rho v$, where K is a crystal constant, ρ is density of medium, and v is propagation velocity. (The term ρv is the *specific acoustic impedance* of the fluid in contact with crystal.) To produce a d-c voltage proportional to ρ, $K\rho v$ must be divided by v. A modified technique for doing this simply is discussed later.

The density sensing transducer is placed into the pipe at the same 45° angle as the other transducers to eliminate the small errors due to fluid velocity.

Computer and Indicator

The signal from the flow elements is a beat-frequency proportional to volumetric rate; the signal from the density elements is a d-c voltage proportional to density. The beat frequency was used to generate voltage blocks with amplitude equal to density signal by use of multivibrators and clamps. The average d-c voltage output (about 70 v full scale) was indicated by a 500-ua indicator. Total flow measurement was obtained by integrating the rate signal in a capacitor-type electronic integrator. The integrator fired a blocking-oscillator type circuit at each 5 pounds of fuel transferred; the pulses were counted by a solenoid-operated drum counter.

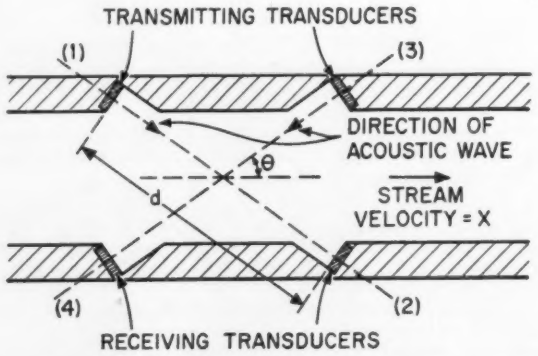


Fig. 2. In early model, transducers were oriented as shown here for flow rate measurement. Time of transmission of 10-Mc energy from transducer 1 to 2 differs from the time of transmission from 3 to 4 by a factor depending only on velocity of fluid in pipe. This difference is used to develop a difference frequency or beat frequency of $(x \cos \theta)/d$, where x is the velocity of stream.

JACK KRITZ

W. L. Maxson Corp.
and consultant,
Fischer & Porter Co.

It has long been the goal of the flowmeter designer to produce a flowmeter having no pressure drop and no obstructions to flow, and unaffected by variables such as temperature, pressure, viscosity, gas bubbles, solids in suspension, or position in installation. This new ultrasonic flowmeter approaches the design goal. It uses the change in velocity of propagation of two 10-Mc waveforms to produce a beat frequency (0 to 50 cps) that is proportional only to flow rate of fluid in pipe. Separate transducer produces signal proportional to mass rate.

Modification for Production Model

The continuous wave carrier technique of Fig. 3 was replaced by a wave-packet system in which a wave-packet generator produces a short train of 10-Mc oscillations on the transmitting crystal. The received packet is amplified and serves to retrigger the packet generator, thus creating the oscillatory loop. A number of advantages accrue from the use of this technique. Since no carrier detection is involved, the build-up time can be sharply reduced by transducer redesign, allowing triggering on an early positive cycle of the receiver signal; the delay instability is thus reduced to a quarter cycle of 10 Mc, or 0.025 microsecond.

The path orientations were also changed from that of Fig. 2. The 45-degree angle was maintained but both paths were placed side by side, allowing use of dual miniaturized transducer assemblies.

The densitometer transducer was redesigned to use a 10-Mc quartz crystal fastened to the rear of a thick metallic window. The window dimension was cut to an integral number of half wavelengths, thus being virtually transparent to the c-w excitation. A further reduction of equipment on the pipe was made by eliminating the procedure of dividing ρv by v. In the computation process, voltage blocks were generated at the difference frequency whose width, instead of being constant, was made proportional to the period of an oscillating loop (1/v) and whose height was proportional to ρv. An output d-c voltage was then obtained proportional to the mass rate.

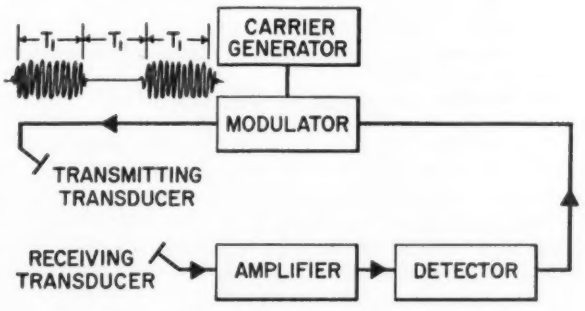


Fig. 3. In early model, time of transmission of ultrasonic energy across pipe caused carrier generator to develop an interrupted train of pulses; duration of each pulse equals time of transmission of energy across pipe. When time of transmission is 100 usec, pulses occur at 10,000 per second, causing oscillator frequency to be 5000 cps. At maximum flow rate in a stream, this frequency is changed by 50 cps, which difference in frequency is measured.

Final production model uses tranducers side by side, and packet wave generator (rather than c-w carrier of Fig. 3) to reduce number of tubes and increase stability and flexibility.

With the decreased size and complexity of the units it became practical to mount both the oscillating loops and the densitometer on a single section of pipe. Each loop contains three vacuum tubes with the densitometer contributing another four. The total tube complement was thus reduced to 10.

Performance Characteristics

The initial 10-Mc design is suitable for a wide variety of fluids from most aqueous solutions through the hydrocarbons. A number of organic fluids display large acoustic absorption in this frequency range; however, successful instrumentation even for these cases can be acquired by lowering the operating frequency. The present design allows a large percentage of beam interruption by solid particles or air bubbles due to the automatic-gain-control features. When the scattering agents become comparable to a wavelength (approx. 0.004 inch at 10 Mc) and are present in sufficient concentration, successful operation will cease. As the scattering attenuation is a function of the fourth power of the frequency, it is evident that moderate reduction of operating frequency can accommodate large classes of impurities.

Velocity Profile

The most significant errors are the ones produced by variations in the velocity profile. As the flowmeter will measure the *average flow velocity* along the beam path, its calculated calibration is true for an infinitely wide rectangular pipe. In the case of laminar flow, the meter will indicate a velocity of 2/3 the maximum center velocity, whereas the true average is given by ½ the maximum. This large difference is not of material importance while the flow is maintained in the laminar region because the relationship is undisturbed by changes in fluid viscosity. The calibration, therefore, will remain correct. For turbulent flow, however, the relationship changes and becomes a function of the Reynolds Number.

Plots were made of expected deviation from calculated calibration for various Reynolds Numbers. From the curves it is apparent that a change of Reynolds Number from 1,000,000 to 30,000 will result in an error of approximately $\pm 1\%$ of a calibrated norm.

Present designs have a capacity up to 12,000 pounds per minute with a fluid density range of approximately 2.5 to 1. It can be adapted to any standard pipe size down to 2 inch. The temperature limit is minus 50 to plus 225 degrees F standard, and up to 750 degrees F with special provisions. The pressure limit is 150 to 300 psig standard, but it can be adapted to higher pressures.

The flowmeter is made from steel, bronze, aluminum, stainless, or other material, depending on the corrosion resistance requirements. Rangeability is 20:1 minimum, linearity is within 1% full scale, and accuracy is better than 2% full scale.

Low-Cost Analog Computer

Availability of a low-cost analog computer with 15 amplifiers and 30 coefficient potentiometers is important news for the instrument department. Unique features include use of null indicator and precision 100-volt reference supply with dividing network to set coefficient potentiometers (and to make voltage measurements) to 0.1%.

CHALMER E. JONES

Heath Company

COMPUTERS are still relatively expensive, running from $1,000 to $400,000 an installation, and the average weighted cost of an analog-computer facility is approximately $60,000.

It is becoming apparent to industry and educational institutions that the computer is an advanced slide rule, a necessary design tool, and a useful means for the engineer, who can play his hunches on a simulator. For example, he may assemble and disassemble a control system five or six times a day by analogy.

Design Factors

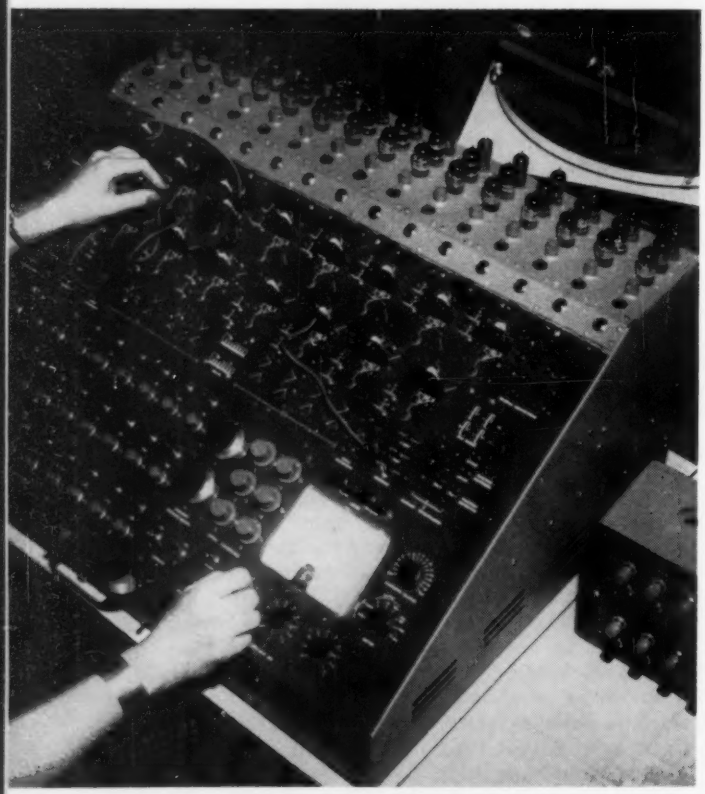
Basically, a computer may be classified by means of four criteria—cost, accuracy, convenience and flexibility. Convenience in general is inversely proportional to the time necessary to set up and reach a solution to a particular problem. A computer is considered more convenient with predetermined integrators, push-button potentiometer setting and removable patch board. A computer is more flexible if the passive resistors and capacitors are not associated with a certain amplifier and can be used as any computing impedance. The following design considerations represent the compromise to achieve low cost with flexibilty.

Readout Indicator

Perhaps the key to the design of this computer is in the readout indicator and its various functions. This indicator (shown at the lower right-hand corner of the computer in Fig. 1) can be used as a means of accurate calibration of the various components. Basically, the unit would be used for the reading of the output of all amplifiers, initial conditions, and other voltages which might appear in the circuitry. In this unit, measurement by nulling was chosen to increase accuracies because the meter sensitivity could be increased to a point where 0.1% readings were easily made. A dividing network capable of dividing a 100-volt reference supply into a thousand steps was chosen. This dividing network is operated by means of push buttons or selector switches. (The selector switch dividing network comprises the four switches below and to the right of the indicator.) The indicator terminals are available for external readout.

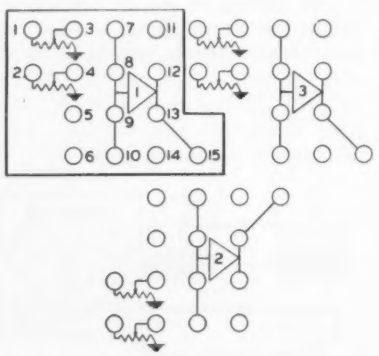
Amplifier Layout

The block in Fig. 2 indicates the chosen layout of an amplifier (amplifier 1). Feedback R-C components may be wired between points 11 and 12, and a short bar between 11 and 7 to make the amplifier a summer or an integrator. Similarly, the feedback impedance could be



← Fig. 1. The low-cost analog computer.

→ Fig. 2. Portion of computer bay showing amplifiers 1, 2, and 3, with amplifier 1 outlined in block. Two potentiometers are located near each amplifier.



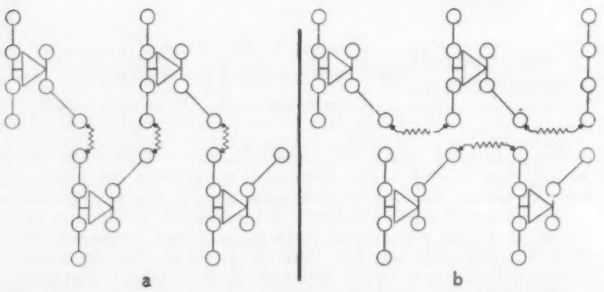


Fig. 3. Methods of connecting amplifiers in series (a) or cross coupling in series (b).

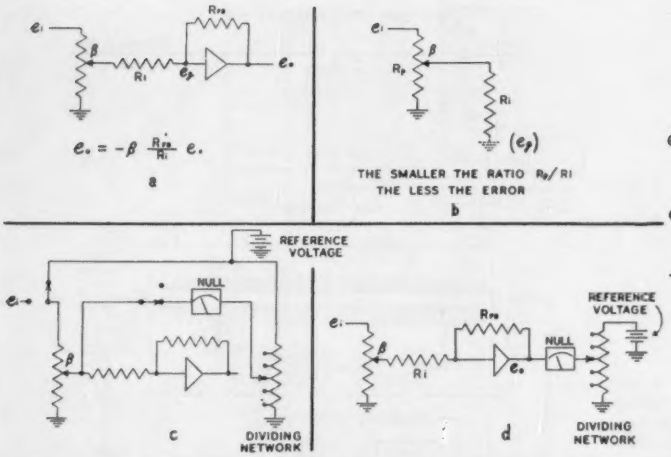


Fig. 4. Potentiometer connections. A shows conventional use. B shows the loading effect because the summing point (input to amplifier) is effectively at ground potential. C shows use of null indicator to set potentiometer at exact voltage desired, thereby eliminating the loading effect. D shows use of null indicator for measuring amplifier output.

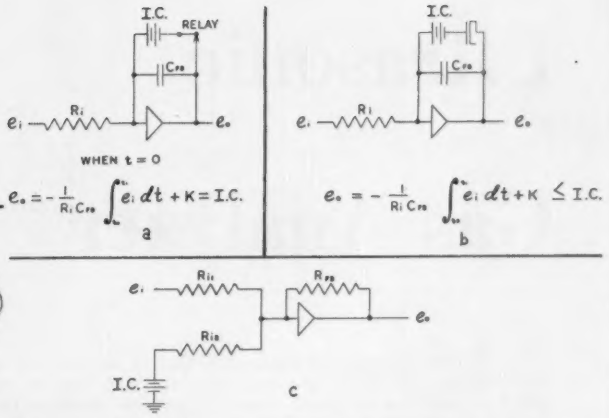


Fig. 5. Methods for use of floating initial-condition (I.C.) power supply to (a) impose an I.C. voltage on a capacitor, (b) bias a diode, or (c) offset an amplifier.

wired between points 13 and 14, with a shorting bar between 14 and 10 to do the same thing. The progression of the computer diagram could be from amplifier 1 to amplifier 2 to amplifier 3 (Fig. 3,a) by means of jumping plugs from point 15 to the grid of the next amplifier (Fig. 2).

Coefficient Potentiometers

These potentiometers multiply a voltage by a coefficient (β) less than one. The schematic is shown in Fig. 4,a. The potentiometer resistance must be relatively low to minimize the loading error of the potentiometer. However, the lower the total resistance of the potentiometer, the more power will be drawn. To overcome these problems and to increase the accuracy and convenience, the coefficient potentiometers are nulled to the standard dividing network, as shown in Fig. 4,c. Note that the loading error and any nonlinear error disappears because the exact voltage desired is measured at the potentiometer arm while connected in the computer circuit. By switching the output of the amplifier to the null position of the readout meter (Fig. 4,d), the gain from input to output may be set. This eliminates error due to mismatch of the input resistance and feedback resistance.

As shown in Fig. 2, there are two coefficient potentiometers associated with each of the 15 amplifiers. This facilitates the functional connections just described.

Initial Conditions

The initial conditions (I.C.) can be introduced by several means. The purpose of an I. C. is to start a particular integrator with some voltage at time zero. Perhaps the most flexible way is by means of a floating power supply; Fig. 5,a shows the connection of such a supply to the plates of a capacitor. This allows for rapid resets and, therefore, repetitive solutions. A floating power supply may be used also to bias diodes (Fig. 5,b) or offset amplifiers (Fig. 5,c).

Diodes

The diodes simulate nonlinear functions such as backlash, dead zone, limits, stops, etc. Since most of these are dual value, two diodes are used and shown on the patch bay as dual units. A diode pair may be seen at the right, in the center row of the patch bay in Fig. 1.

Relays

The computer is reset and operated by means of entering initial conditions to the integrator. Relays must be operated for each capacitor. A second use of relays is to hold a problem in the midst of solutions, to enter new information or for recording purposes. Therefore, two sets of relays should be supplied. To increase the flexibility, the relay coils are connected to a jack on the patch bay. One relay set may be operated by means of the output of an amplifier to serve as a functional relay. A relay set can be seen in the center of the computer panel.

Function Generators

Several types of nonlinear function generators are manufactured and any can be used. Perhaps the most flexible for a unit of this size is a bias-diode straight-line single-function generator (shown as an auxiliary to the right of the computer in Fig. 1). The unit could be set up by means of the null readout meter and the dividing network.

Other nonlinear units (multipliers, servo multipliers, and special-purpose units) can be used in conjunction with the computer. These would be connected to the patch jacks by cabling to external connectors.

The computer is capable of being slaved to or mastering other computers. This enables its expansion to more than 15 amplifiers, which was the quantity chosen for one unit. To provide for this, all grids and outputs are brought to an inter-connecting bay at the rear of the computer.

Summary

The key to a low cost, flexible unit was found in using a standard voltage-reference supply and a dividing network. This one feature allows an accurate measurement of: (1) coefficient setting, (2) over-all gain from input to output of the amplifier, (3) initial-condition set, (4) bias-diode setting, (5) set up of function generator, and (6) throw voltages for operational relays.

The layout of the amplifiers allows a minimum of plugging and wiring and includes thirty, nulled, coefficient potentiometers. The computer layout can be altered to meet demands of industry.

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Ultrasonic Gas Analyzer

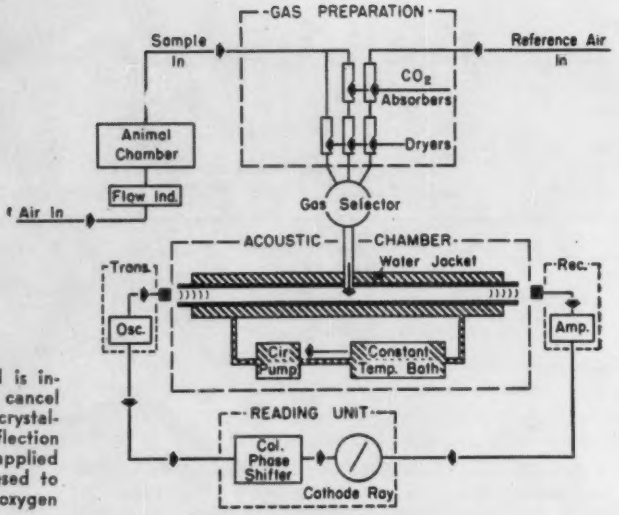

Fig. 1. Block diagram of equipment. Gas to be analyzed is introduced into center of tube and flows out both ends to cancel effect of gas flow on sound velocity. Oscillator develops crystal-controlled 150.1-kc signal, which is applied to vertical-deflection plates of CR tube. Received signal at other end of tube is applied to horizontal-deflection plates. Calibrated phase shifter is used to balance the phases of the two signals. Sensitivity is 0.0036% oxygen per division capacitor change.

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and
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Merck Institute for
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Measurement of basal metabolic rates requires measurement of 0.01% change in oxygen concentration. An apparatus with the required sensitivity is described, and its application for measurement of oxygen uptake and respiratory quotient. Principle is measurement of phase change caused by change in velocity of sound wave.

INSTRUMENTS such as the Pauling meter for oxygen, the Lilly nitrogen meter and the Fowler infrared analyzer are available for the analysis of specific gases. These instruments are sensitive and give practically instantaneous response. However, for studies involving the determination of respiratory quotients, instruments are required for measuring both oxygen and carbon dioxide, and the problem of frequent calibration arises. The thermal-conductivity bridge also has been adapted for use in measuring the percentages of oxygen and carbon dioxide in respiratory gases; this method is sensitive but is extremely critical in operation. The ultrasonic gas analyzer here described, while nonspecific for the individual gases, has the advantage of being highly sensitive, stable in operation, simple to manipulate and economical in technician time. For example, to carry out, using standard chemical methods, the sixty odd gas analyses required in one day in the animal experiment to be described would have taken about 20 hours of technician time. Additional time would be necessary for setting out the animals and performing other experimental details. Using our equipment one operator easily completed all of the experimental work within an eight-hour period.

Although the sonic gas analyzer was devised primarily for the study of respiratory gases, its flexibility and sensitivity suggest many other possible applications among which are: Monitoring of gas mixtures that are made up on a continuous flow basis since inherently the response is practically instantaneous and the sensitivity is the same over the range of 0 to 100 percent; analyzing mixtures of inert gases; testing the effectiveness of various gas absorbers at different flow rates; determining whether a gas sample is homogeneous, and following relative changes in the concentration of isotopes in certain gases.

Using the velocity of sound for analyzing gas mixtures is not new. However, none of the sonic instruments described in the literature are sufficiently sensitive to detect changes in the order of 0.01% in the oxygen concentration in respired air, a requirement in equipment for the determination of basal metabolic rates in laboratory animals. An apparatus has been developed having the required sensitivity.

Principle

When a sound transmitter and receiver are separated by a fixed distance, and sound at a constant frequency is emanating continuously from the transmitter, a certain phase relation will exist between the sound wave at the points of transmission and reception. If the sound propagating medium is changed, this phase relationship will change because wavelength is a function of velocity. The variation in phase will be magnified in direct proportion to the number of waves present between the transmitter and the receiver. Hence, it is possible to increase sensitivity either by lengthening the sound path or raising the frequency. The practical limit depends on the constancy of the frequency, temperature, and the characteristics of the electronic and mechanical elements employed: Too high a frequency presents problems in radiation, availability of transducers and measurement of phase. A long path length requires a large volume of sample gas. The accuracy of the phase-measuring elements determines the minimum values of both frequency and path length.

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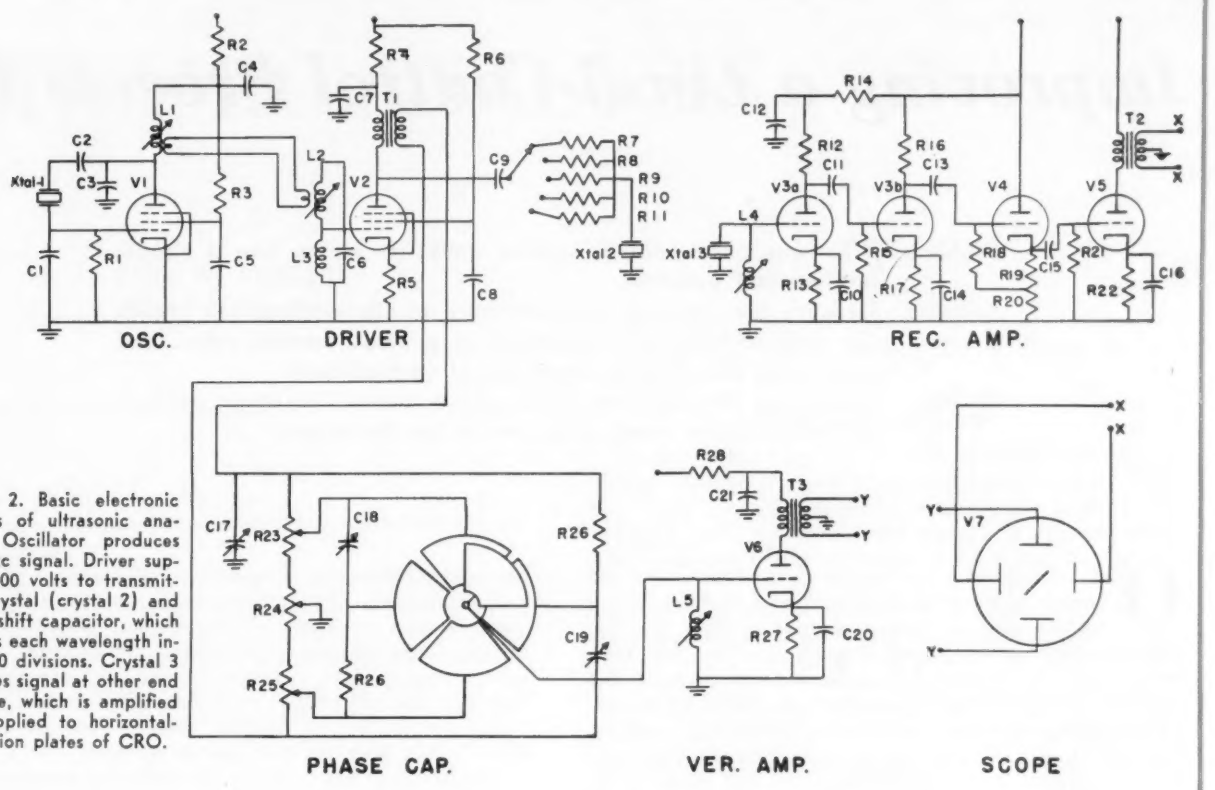

Fig. 2. Basic electronic circuits of ultrasonic analyzer. Oscillator produces 150.1-kc signal. Driver supplies 100 volts to transmitting crystal (crystal 2) and phase-shift capacitor, which divides each wavelength into 1000 divisions. Crystal 3 receives signal at other end of tube, which is amplified and applied to horizontal-deflection plates of CRO.

Description of Equipment

The acoustic chamber is a smooth metal tube 8 mm in diameter, 100 cm long, surrounded by a jacket through which water at a constant temperature is circulated to maintain the gas in the tube at a fixed temperature (Fig. 1). The gas to be analyzed is introduced at the center of the tube and flows out both ends. This arrangement cancels the effect of gas flow on sound velocity by establishing equal and opposite velocities of flow.

Piezoelectric crystals, mounted in the tube about 3 cm from each end, serve as transducers for transmitting and receiving acoustic energy. Forty-five-degree Z-cut ADP (ammonium dihydrogen phosphate) crystals resonated at 150.1 kc are used.

The oscillator frequency (Fig. 2) is crystal controlled at 150.1 kc and adjusted for a good waveform. The driver amplifier supplies 75 to 100 volts to both the transmitting crystal and the phase-splitting network that precedes the calibrated 360° phase-shift capacitor (which divides each wavelength into 1000 divisions). The output of the phase-shift capacitor is amplified and applied to one pair of deflection plates of the cathode-ray tube. The output of the receiving crystal is also amplified and applied to the other pair of deflection plates. The 45° line of the Lissajous figure is used as the null-point indicator; phase-change measurements are made by observing the number of divisions the phase capacitor has to be displaced to reestablish the straight line on the oscilloscope.

With dry, atmospheric air flowing through the tube at a rate of 100 cc per min, the sensitivity to oxygen is 0.00360 percent per division. The drift is less than 1 division over a 5 to 10 minute period. The long-time reproducibility is better than ±10 divisions over several days.

Operating Characteristics

To calculate the theoretical phase change an equation relating gas percent and phase change was developed from the ideal gas equation (neglecting the equivalent ratio of specific heat).

The calculated and observed values of the phase change are summarized in Table II. The close agreement obtained indicates the possibility of predicting the operating curve when the ratio of the relative velocities is known. This materially simplifies the calibration. The basic equation becomes more involved when the mixture contains more than two gases and specific heat ratios have to be considered.

To determine the oxygen sensitivity of the equipment the phase change between reference air and a sample of oxygen-free air was measured. In repeated tests made on different days this phase change was found to be 5.820 ±0.001 wavelengths or (to express it in the units used in our calculations) 5,280 divisions. This figure divided into 20.946 (the percentage of oxygen in carbon-dioxide-free air) gives an oxygen sensitivity of 0.003599% oxygen per division.

Table II—Measured vs Calculated % Phase Change in Oxygen-Nitrogen Mixtures.

Per cent Oxygen in Mixture	*Phase Change Observed*		*Calculated*
	Divisions	*%*	*%*
0	0	00.0	00.0
25	7,104	25.63	25.63
50	14,095	50.857	50.83
75	20,956	75.612	75.62
100	27,715	100.00	100.00

Improving a Level-Control Process by

Problem: **Why won't the control system work? It seems like a simple level-control problem.**

Solution: **Measure the physical characteristics of the equipment. Obtain the transfer-function description of process, control valve, and connecting line. Plot the response of each element.**

Result: **Connecting line between externally mounted float-type controller and receiver vessel turns out to be the culprit.**

ONE STAGE of a continuous flow process required control of the level of a liquid seal in a small connecting pipe between two vessels (Fig. 1). The rate at which liquid passed through the pipe was relatively high (¾ ft/sec). Owing to location of units, the original installation was made using an externally mounted float-type controller connected to the receiver vessel by 35 ft of 2" pipe. Control performance was unsatisfactory and, as a result, a post-mortem analysis was made to determine the cause and correct the condition.

Means of Analysis

Physical measurements of the equipment were obtained and a mathematical analysis of the time behavior of (1) line connecting receiver vessel to float housing, (2) control valve, and (3) process time-constant was made. Other factors (response of transmitter, pneumatic connecting lines, and controller) were not included in the first approach. Also, a simplified control valve behavior was assumed (normally, experimentally derived curves would be used for the control valve). These simplifications do not alter the conclusions reached.

The first step was to obtain the following transfer-function descriptions of connecting pipe, valve, and process.

Transfer Function for Connecting Pipe

$$\frac{\mathbf{H}_1}{\mathbf{H}} = \frac{1}{(1.9S^2 + 0.023S + 1)}$$

Transfer Function for Valve

$$\frac{\mathbf{Z}_o}{\mathbf{P}_v} \approx \frac{0.1}{0.7S + 1}$$

Transfer Function for Process

$$\frac{\mathbf{H}}{(\mathbf{Z}_1 - \mathbf{Z}_o)} = \frac{1.25}{S}$$

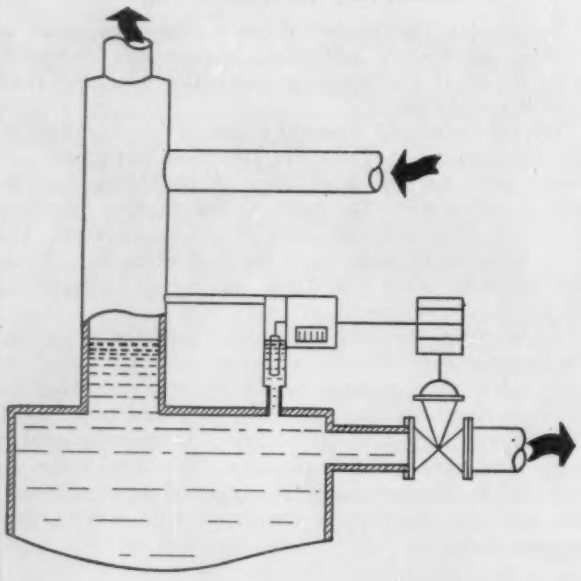

Fig. 1. The level control problem. Level of liquid seal in pipe connecting two vessels must be controlled. Rate at which liquid passes through connecting pipe is rapid (¾ ft/sec). Externally mounted float-type controller is chosen. Location of units is such that controller is connected to the receiver by 35 feet of 2" pipe.

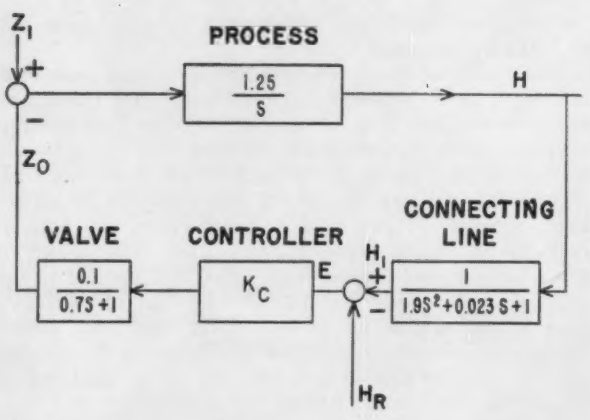

Fig. 2. Signal flow diagram shows transfer-function descriptions of each element in control system. Simplified valve response is assumed. Controller response is not considered in first approximation.

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DYNAMIC ANALYSIS

CARL W. SANDERS
E. I. duPont de Nemours & Co.

Transfer Function for Controller

$$\frac{\mathbf{P}_c}{\mathbf{H}_1} = K_c$$

(a constant, because process dynamics are not a factor in this example).

where $\mathbf{H}$ = Laplace transform of h, the liquid height above reference level in main vessel

$\mathbf{H}_1$ = Laplace transform of h_1, the liquid height above reference level in float housing

$\mathbf{Z}_o$ = Laplace transform of z_o, the flow rate out of vessel through valve

$\mathbf{P}_v$ = Laplace transform of loading pressure on valve

S = Parameter which appears in the transfer function in place of dh/dt; and S^2 is a parameter appearing for d^2h/dt^2.

Open- and Closed-Loop Transfer Functions

The next step was to obtain the open- and closed-loop transfer functions. Fig. 2 shows the signal flow diagram and the contribution of each frequency-sensitive element in the open-loop transfer function, which is:

$$\frac{\mathbf{H}_1}{E} = \frac{0.125\ K_c}{S(0.7S + 1)(1.9S^2 + 0.023S + 1)}$$

Where E = Difference between $\mathbf{H}_1$ and $\mathbf{H}_R$, and $\mathbf{H}_R$ = Laplace transform of h_r, the reference or set point level.

The closed-loop transfer function is:

$$\frac{\mathbf{H}_1}{\mathbf{H}_R} = \frac{KG}{1 + KG}$$

$$\text{where } KG = \frac{0.0094}{S(0.7S + 1)(1.9S^2 + 0.023S + 1)}$$

Response Analysis

The open-loop response of each element is shown by plotting attenuation and phase shift vs frequency. The magnitude ratios are plotted in Fig. 3; the phase shifts in Fig. 4. At this stage of the analysis it becomes clear that the source of the difficulty is the liquid connecting line.

Fig. 5 is a plot of attenuation vs phase shift and a superposed 2-db Nichols curve. From this a control gain of 0.075 psi/ft change in level is obtained. This K_c controller gain value is not practical.

The connecting line, obviously the source of trouble, was studied in greater detail by plotting its amplitude and phase change vs frequency. This revealed that the resonance in the connecting line was the major source of trouble. The designer has two courses of action:

1. The natural frequency of the connecting line can be increased. This can be done either by shortening the line or increasing the spring rate of the measuring system by replacing the float transmitter with a diaphragm or bellows-type differential-pressure transmitter.

2. Amplitude at resonance can be reduced by increasing the damping (reducing the diameter of the connecting line or introducing a restriction orifice). However, this introduces time delay which slows recovery time.

The connecting line was shortened to less than 1 foot, and the connecting-line diameter was reduced. An alternate and preferred solution would be use of a force-balanced d-p transmitter instead of the tubular float transmitter.

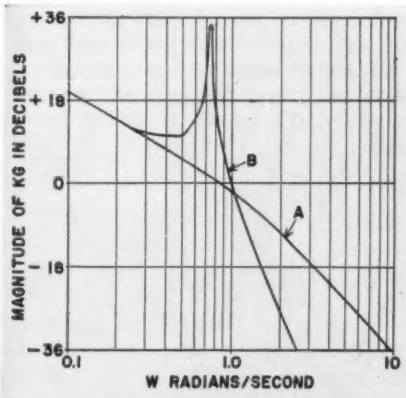

Fig. 3. Open-loop response of system elements. Curve A shows attenuation, or output/input magnitude ratio for process plus valve. Curve B includes connecting line, which shows up as the source of resonance at frequency of 0.73 radians/sec.

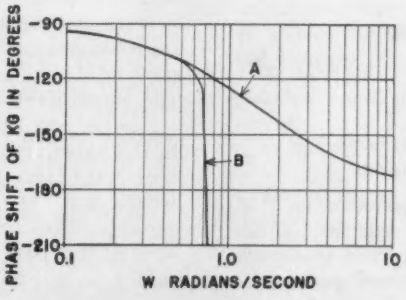

Fig. 4. Phase shift vs frequency for process and valve (curve A) and process plus valve plus connecting line (curve B). Source of difficulty is clearly the connecting line between process and controller.

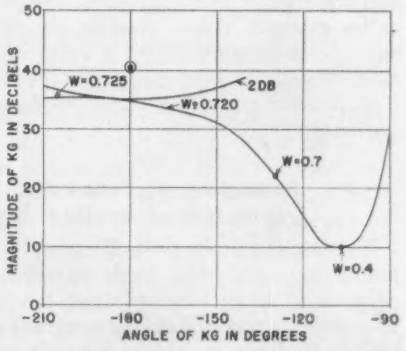

Fig. 5. Plot of attenuation vs phase shift and superposed 2-db Nichols curve. From this a control gain of 0.075 psi/ft change in level is obtained. The controller gain value is not practical.

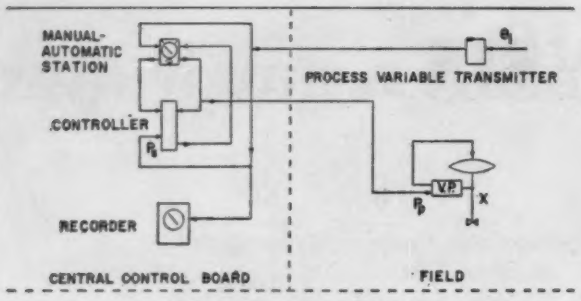

Fig. 1. Typical board-mounted control system.

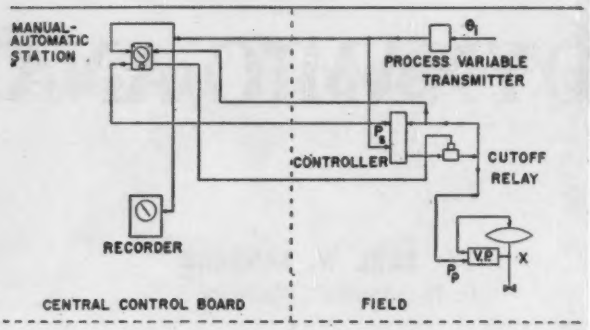

Fig. 2. Typical field-mounted control system.

Dynamics of Pneumatic Control Systems

A dynamic analysis of a pneumatic control system can begin with the testing of individual elements in the closed loop. Response of a board-mounted controller is discussed in detail, giving attenuation for various signal levels, transmission-line lengths, etc. A technique is presented for compensating of transmission-line length by modification of the transmitter feedback.

PAGE S. BUCKLEY
E. I. du Pont
de Nemours & Co.

IN THE design of electronic equipment, it is standard practice for the designer to employ the techniques of impedance matching. But this philosophy does not work too well in the case of pneumatic equipment. The reason is that the concept of impedance matching seems to be largely lacking, at least in a dynamic sense. Therefore, we have finally come to a point of view that the basic problem is not to test individual instruments, as such, but rather to test segments of a control system. This means that we measure from a point at which the system is noninteracting to another point at which the system is noninteracting. This eliminates the problem of loading; as for example, that caused by the volume at the termination of a pneumatic line. A point of noninteraction, incidentally, is a point at which the shunt impedance is high relative to the impedance of the system segment being tested.

Reduction of Pneumatic Systems Into Noninteracting Segments

The starting point for any testing program, or for that matter any analytical work on control systems, is the preparation of an accurate signal-flow diagram. One must first look at the signal-flow diagram of a proposed system to find out at which points it may be cut into independent, noninteracting segments. The testing program then reduces to testing segments of the system.

The two commonest patterns are the board-mounted or long-loop system (Fig. 1), and the field-mounted or short-loop system (Fig. 2). A third pattern, which is essentially short-loop but modified to give much faster performance, is also coming into use.

Board-Mounted System

A typical board-mounted control system is shown in Fig. 1. This system may be cut into three sections for analysis or testing.

The *first* is from the transmitter input to the controller input signal pressure P_s. (It is assumed that the transmitter input presents a high impedance to the signal; that is, it does not load the signal source.) The transmitter output impedance, however, is not zero and transmitter performance is affected by (a) length of tubing from transmitter to controller, (b) tubing diameter, (c) volume and mechanical compliance of receiving elements, (d) signal level, and (e) signal amplitude.

The *second segment* is from the controller input, P_s, to the valve input pressure, P_p. The controller-input volume and mechanical compliance are usually small, which means that the controller usually has a high input impedance. The factors which affect the dynamic performance of this part of the control system are: (a) length of tubing from controller output to valve input, (b) tubing diameter, (c) volume and mechanical compliance of valve input, (d) signal level, (e) signal amplitude, (f) nature of restrictions in manual-automatic station, and (g) in some cases, the proportional-band and reset settings.

The *third segment* is from the valve input to the valve-stem position, x. This may be divided into five basic cases: (1) Spring-and-diaphragm valve with no auxiliaries. The transfer function here is measured or calculated

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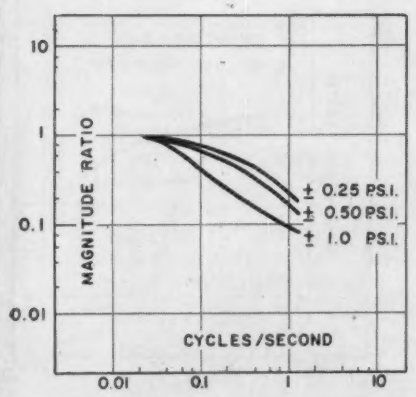


Fig. 3. Effect of signal size on frequency response (attenuation vs frequency) of board-mounted pneumatic controller of conventional stacked type.

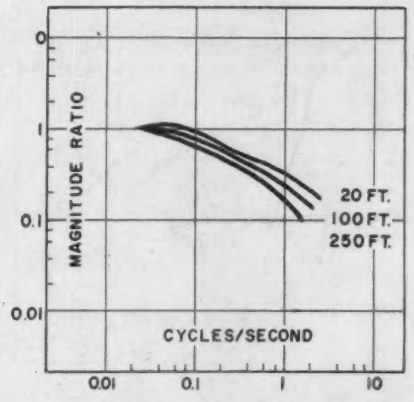


Fig. 4. Effect of transmission-line length on response of board-mounted controller.

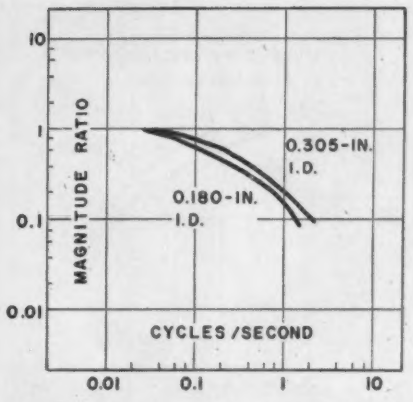


Fig. 5. Effect of transmission-line diameter on response of board-mounted controller.

from the pressure in the topworks to the stem position. (2) Spring-and-diaphragm valve with positioner. Performance is defined between the input to the valve positioner and stem motion. (3) Spring-and-diaphragm valve with booster. Again, performance is defined between booster input and stem position. (4) Spring-and-diaphragm valve with positioner plus booster. Performance is measured from positioner input to valve-stem position. (5) Positioner-actuated valve with integral positioner.

Field-Mounted Control System

A typical field-mounted control system is shown in Fig. 2. This system may be divided into the same three sections as the board-mounted system: (1) From transmitter input to controller input. (2) From controller input to valve input. (3) From valve input to valve-stem position. The important parameters are: signal level, signal size, line diameter and length, line termination, and branch loads.

Effect of Signal Level

Our data on the effect of the signal level are not too extensive but, in general, they indicate that a pneumatic system responds faster for a higher level of average pressure.

Effect of Signal Size

Signal size is one of the most important of all pneumatic-control-system parameters. In general, for very small signals (1/10 psi or less) one is apt to run into problems of static friction and hysteresis, particularly in the case of control valves. On the other hand, for large signals (1½ to 2 psi or greater) there is a tendency for the control system to saturate due to the fact that the pilots are already wide open and cannot open any further and permit more air to go through. Fig. 3 illustrates the effect of signal size on the magnitude-ratio portion of the frequency response for a typical pneumatic stacked controller, installed as in Fig. 1, except that the load is the topworks of a 6-in valve. The controller was connected through the manual-automatic station to the valve by 250 ft of ⅜-in tubing. Reset rate in this and succeeding tests was set at minimum; throttling range was either 100 percent or corrected to 100 percent. As expected, the frequency response fell off more rapidly for the large signals than for the small ones.

Effect of Transmission-Line Length and Diameter

In general, for a long length of pneumatic transmission line the attenuation is severe. The effect of line length on attenuation is illustrated in Fig. 4. The experimental setup in this case consisted of various lengths of ⅜-in tubing, controller, manual-automatic station, and a 6-in valve.

The effect of transmission-line diameter is illustrated in Fig. 5.

Effect of Load Volume

Ideally, the pneumatic transmission line should be terminated in its characteristic impedance. This almost never occurs. The effect of volume of termination on frequency response is illustrated in Fig. 6. Two different terminating volumes were chosen: valve-positioner input bellows, and the topworks of a 4-in valve. The controller was coupled to the load through a manual-automatic station by 250 ft of ¼-in o.d. tubing. As might be expected, the valve topworks gave far greater attenuation than did the positioner bellows; the positioner-terminated system is about twice as fast.

Effect of Manual-Automatic Station

Fig. 7 shows that the effect of a typical station is marked. The rest of the load consists of 250 ft of ⅜-in tubing and a 4-in valve.

Effect of Branched Loads

To measure the effect of branching we set up a field-mounted controller with a cutoff relay, 10 ft of ¼-in tubing, and a valve positioner. The branched line was ¼-in tubing which went 250 ft back to the board. Fig. 8 shows the frequency response with and without the branch. Considerable improvement resulted from isolating or removing the branch.

General Transmitter Theory

After having studied the action of a number of relays and transmitters we have concluded that their performance may be generalized by a single basic theory. A transmitter contains the following elements (Fig. 9):

1. Comparison circuit, where the input signal is compared to the feedback signal to produce the error signal.
2. Error-amplifier circuit; usually a flapper-nozzle combination.

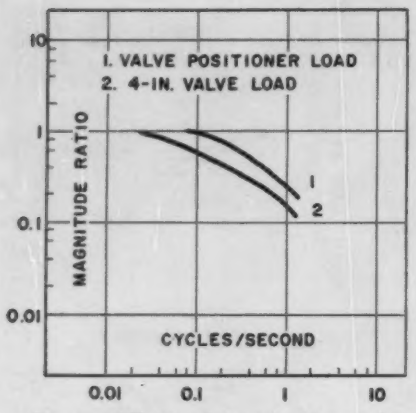


Fig. 6. Effect of termination volume on response of board-mounted controller.

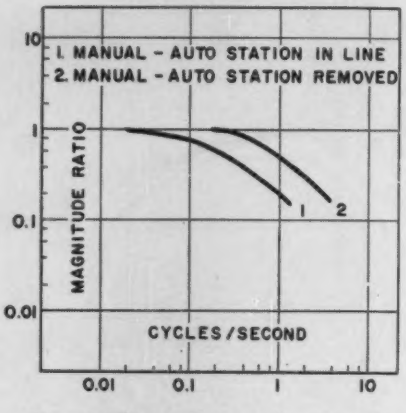


Fig. 7. Effect of manual-automatic station on response of board-mounted controller.

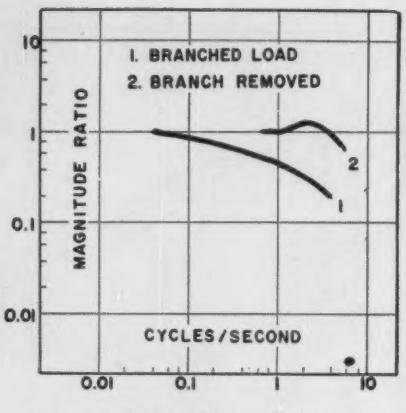


Fig. 8. Effect of branched loads on board-mounted controller.

3. Power amplifier; either a spring-loaded, three-way pilot valve or a dual valve (non-bleed) pilot.

4. Feedback circuit, which provides a path through which the signal at the immediate transmitter output is fed back to the comparison circuit.

5. The load, which consists of tubing, single or branched paths, valves, restrictions, and terminations.

The signal flow diagram for the general transmitter is shown in Fig. 9. The performance may be defined as the response P_1 to an input signal θ:

$$\frac{P_L}{\theta_i}(j\omega) = \left(\frac{K_1G_1 \times K_2G_2 \times K_4G_4}{1 + K_1G_1 + K_2G_2 + K_4G_4}\right) \times \left(\frac{1}{K_4G_4}\right) \times (K_3G_3) = K_5G_5 \times K_3G_3$$

where the K's are frequency invariant and the G's are complex, dimensionless functions of frequency, ω.

As a general rule all dynamic elements within the device itself will respond to a signal much faster than the load at the end of the transmission line will respond. This has led to a widespread opinion that pneumatic transmission-line lags constitute a fundamental limitation in the pneumatic control system. This is true, but as we shall show, it is not as critical as commonly believed.

Transmitter with Modified Feedback

Fig. 10 represents a rearrangement of Fig. 9. It shows that the relationship between θ_i and P_L may be represented by a single loop. The ratio P_L/θ_i is the same as in the first expression given above. If now the feedback dynamics, G_4, were made equal to the transmission-line dynamics, G_3, the feedback path would contain no dynamics. In effect, this closes the loop around the transmission line, thereby greatly enhancing performance. An examination of some transmission-line data indicates that by this method it should be possible to improve P_L/θ_i by 500 to 1,000 percent. To achieve this, however, it would be necessary to increase the pilot-valve capacity of the average transmitter or relay.

Tests with Modified Transmitter

Fig. 11 shows what happens when a flow transmitter with a 250-ft tubing load has its feedback circuit modified to roughly compensate for the lag of the transmission line. It can be seen the dynamics of the transmitter are improved by approximately 300 to 400 percent. Failure to achieve the predicted 500 to 1,000 percent is due almost entirely to the fact that we were able to use only a simple RC circuit, whereas a circuit of considerably greater complexity would have been required for good approximation. We feel, however, that this test demonstrates the feasibility of this idea.

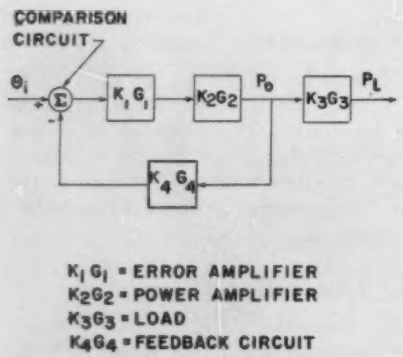


Fig. 9. Block diagram of a generalized transmitter where G terms are complex, dimensionless functions of frequency; K's are frequency invariant.

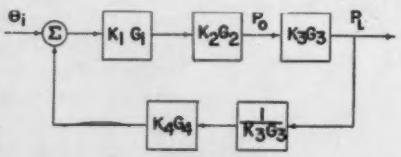


Fig. 10. Rearranged signal-flow diagram of a transmitter.

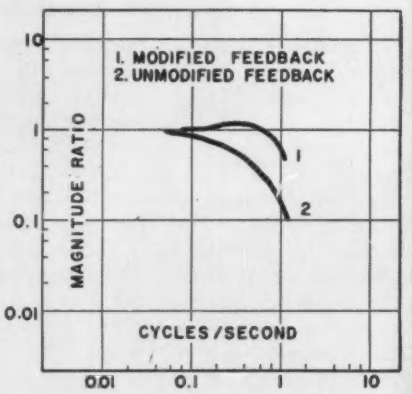
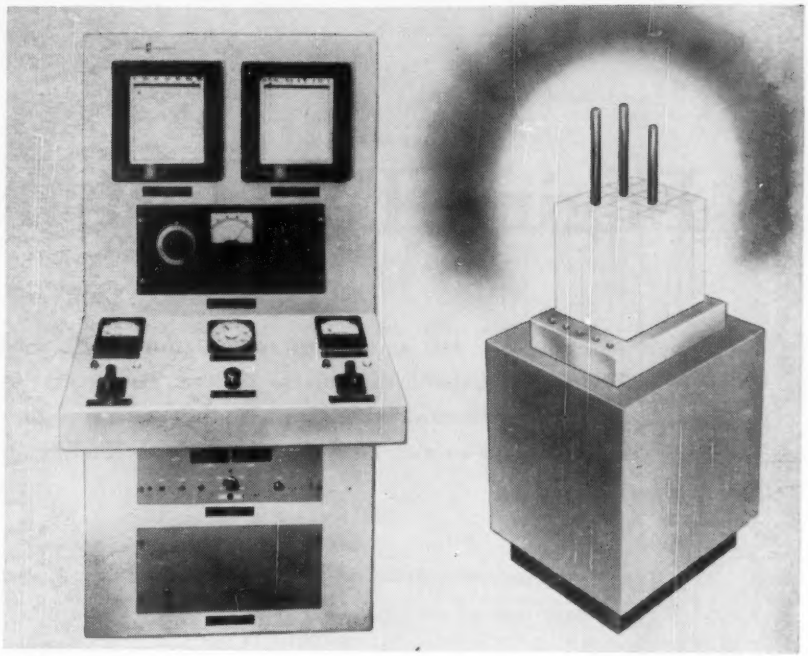


Fig. 11. Effect of modified feedback on frequency response of transmitter.



Nuclear-reactor simulator comprises an instrumentation and control panel, and a plastic model of a reactor. At top left on the panel is a linear flux recorder; at right, a period recorder. Just beneath is the Simulator, an electronic analog computer. Indicators on the sloping shelf indicate Log N, rod position, and log count rate, and switches provide rod control.

REACTOR SIMULATOR

ONLY 250 new nuclear engineers will be graduated this year, but 15,000 specialists in the expanding field of nuclear power and nuclear reactors will be needed by 1965. Further, despite an expected large increase in the number of experimental nuclear reactors in universities and research laboratories, few engineers will have the opportunity to start, stop, and investigate nuclear reactors by actual experience—and there is no substitute for such basic instruction. It is this combination of circumstances that gives significance to the development of a reactor simulator.

The Simulator

The Nuclear Reactor Simulator* consists of two basic units: (1) a plastic scale-model of a reactor core, approximately two feet high, mounted on a pedestal-type bench, and (2) a full-size control panel, complete with instrumentation and controls. The scale-model is equipped with mechanisms to drive the reactor rods up and down. Also provided are blue lights whose voltage is controlled automatically to simulate the Cerenkov effect.

Mounted on the control panel are two recorders, one for recording power level (range 0 to 120% full power), the second for recording period (range −30 to infinity to +3 seconds). Also mounted on the panel console is the simulator unit (an electronic analog computer that solves continuously the differential equations representing the kinetic operation of a reactor) and a servo amplifier, logarithmic amplifier, power supply, and related switches, meters and signal lights.

*Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia 44, Pa.

Basic Functions

For educational and research institutions which have or plan to build reactors, the Simulator can serve both for personnel training and for reactor instrumentation testing. For institutions which do not have reactors, the Simulator is useful in dynamically teaching and demonstrating principles of reactor theory and performance.

In teaching reactor theory the equipment is particularly valuable in demonstrating the kinetic equations involved in reactor engineering.

With this Simulator, the trainee can learn how to start up, maintain, increase and stop the chain reaction. He can learn the principles of reactor theory and performance. Complex kinetic equations can be demonstrated graphically; he can actually "see" the results of altering certain of the variables. He can see the delayed neutron effects "on the way down" and the integrating effects "on the way up." The trainee can become thoroughly familiar with "authentic" reactor instrumentation; the recording and controlling instruments on the Simulator panel are similar to those supplied for the Geneva reactor, and for the reactor at Pennsylvania State University.

The Simulator can simulate a number of types of thermal nuclear reactors, among them:

(1) Swimming Pool Type—light water moderated, enriched.
(2) Graphite Moderated Natural Uranium.
(3) Heterogeneous Heavy Water Moderated (CP5 Type).
(4) U233 Thermal Reactor.
(5) PU239 Thermal Reactor.

Engine Test Instrumentation

This report describes the engine test instrumentation being used by the Research Laboratories Division of General Motors. The requirement and opportunity to make a complete instrumentation review came in conjunction with the move to the new General Motors Technical Center.

A. F. WELCH
and
G. M. RASSWEILER
Research Laboratories Div.,
General Motors Corp.

The Dynamometer Building

FIG. 1 shows a floor plan of the typical arrangement of two test cells with the associated control room between them. There are two bullet-proof observation windows, one for each test cell. To further reduce danger from engine breakups, neither window is opposite an engine. Each window affords a quartering view of the engine and some are arranged to slide open, if desired, so that engine sounds may be detected. A control and instrument console may be placed in front of the window in the control room or inside the test cell.

Instrumentation

The first eight variables in Table I are measured in almost every test made on an internal combustion engine. The last two variables are measured frequently.

Table I—Variables Most Commonly Measured in Engine Test Work

1. Time
2. Speed
3. Torque
4. Fuel Consumption
5. Ignition Timing
6. Temperatures
7. Pressures and Vacuums
8. Atmospheric Pressure and Humidity
9. Air Consumption
10. Mixture Ratio

Instruments used to measure these quantities will be called "standard instruments" to denote that they are used in every test cell, and are, to a large extent, the same in all test cells (not to be confused with calibration standards). These are to be distinguished from "special instruments" of great variety, depending on the particular problem being investigated.

All standard instruments are available from commercial sources. To get the operators out of the test cells, most of the instruments are remote reading.

Time

Elapsed time is measured by reference to the commercial 60-cycle lines. This accuracy (between 59.8 and 60.2 cps) is adequate for most purposes. The maximum deviation ever recorded was a low of 59.2 cps and a high of 60.7 cps, and these were short-period deviations. This means that errors in time measurements to this base seldom exceed 0.3%.

Two instruments for measuring elapsed time are provided in every dynamometer room: (1) A stop clock; manually operated for general purposes or used as an automatic elapsed-time indicator for counting revolutions or measuring fuel consumption; accuracy can be no better than the 60-cycle time base. (2) A running time meter.

Speed

The method used eliminates the need for a cathode-ray synchronizer for setting engine speed and replaces the revolution counter and instantaneous speed indicator (speedometer) formerly used. The method (suggested by John D. McCullough of Ethyl Research Laboratories) uses an electronic device to count the impulses generated during a fixed time period by a gear driven from the dynamometer shaft. We developed a 180-impulse-per revolution magnetic pickup which operates at ½ crankshaft speed. As the pickup gives 90 impulses per engine revolution, the count can be made equal to the rpm by setting the fixed time period of the counter to 1/90 of a minute. The count is displayed as an illuminated figure on a panel, is then automatically erased, and 2/3-second later a new count appears. This instrument is now available from commercial sources complete with magnetic pickup.

The accuracy of this type of tachometer is equal to that of its time base within ± 1 rpm. There is no error due to mechanical clutching. Forty cycles of the 60-cycle frequency are used to furnish the 2/3-second counting time. Speeds from 100 to over 6,000 rpm have a direct reading accuracy within ± 0.3% ± 1 rpm. The accuracy can be increased readily, if necessary, by supplying a more accurate time base and/or by making each count represent 1/10 rpm.

Torque

Good torque measuring accuracy is being achieved by the combination of three things:

1. Oil-floated bearings for dynamometers. This development reduces the cradle bearing friction to a negligible value.

2. Cradling the tachometer and other accessories driven by the dynamometer shaft. When these instruments are not mounted on the cradle, their driving torque is sup-

*Abstracted from ISA Paper 55-24-2, presented at ISA National Conference, Los Angeles, Sept. 16, 1955. Complete paper is available from ISA, 1319 Allegheny Ave., Pittsburgh 33, Pa.

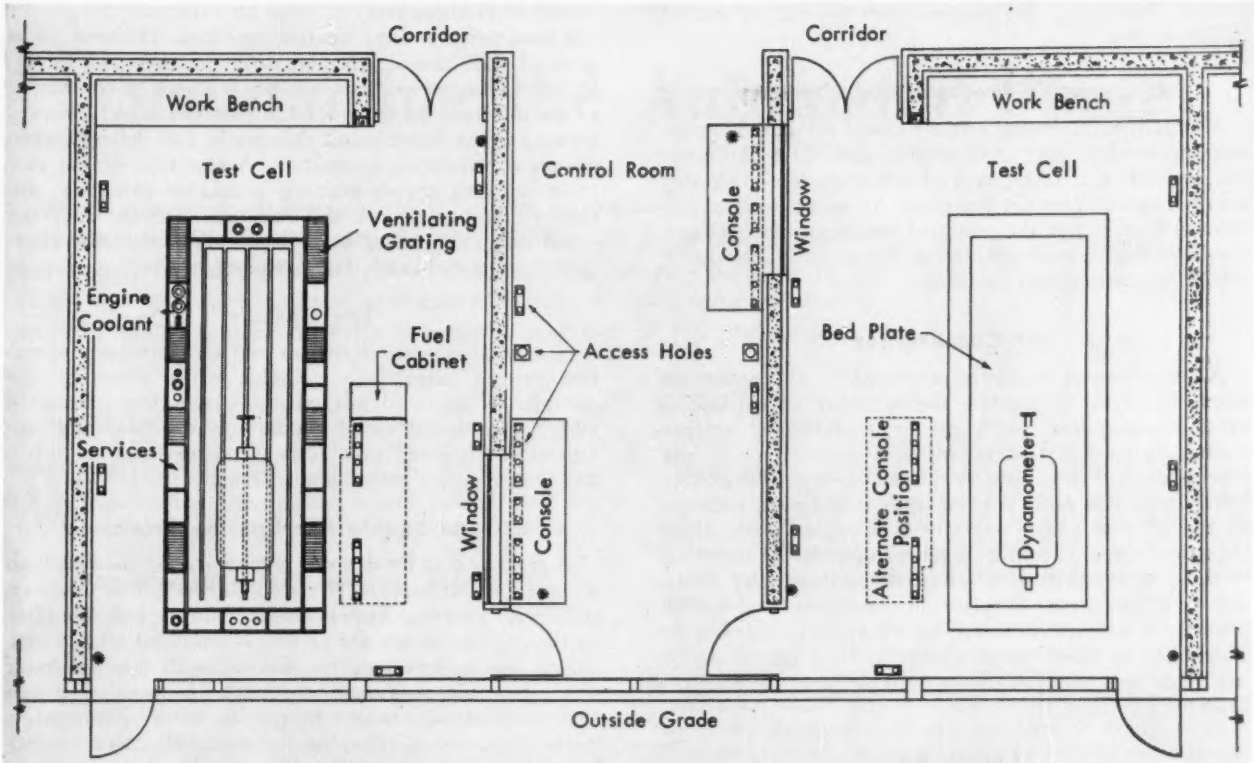


Fig. 1. Layout of two engine-test cells with control room between cells. ● - Emergency Stop Buttons

plied by the engine but is not measured by the dynamometer. The torques are generally insignificant but may amount to a few percent in the case of faulty lubrication or low-efficiency reduction gears.

3. Use of a good torque weighing device. Three types of torque scales are being used with success; springless scales, pneumatic and hydraulic force-balance systems.

Fuel

Accurate measurement of fuel is necessary for the detection of small changes in engine efficiency. For several years the Laboratories have been using automatic contact-making burettes; they have been chosen as the standard means of measuring fuel. With careful calibration, using an electrolyte to displace gasoline, a system can be produced that has a maximum error of ± 0.5%.

One of the important features of the burette system is that it is remote reading. In the interests of safety, no gasoline is brought into the instrument console. Gasoline is brought into the dynamometer room at the side of the bedplate, metered at this point, and delivered directly to the engine.

The burette, being an integrating device, does not indicate instantaneous rate of flow. A careful investigation of commercial flowmeters of the instantaneous type has convinced us that none of these instruments will give an accuracy comparable to the burettes at the flow rates used in automobile engines. However, there appears to be a need in some test cells for an instantaneous, continuously indicating, rate meter of moderate accuracy to determine whether fuel flow is constant.

Ignition Timing

The spark advance angle of an engine on a dynamometer has, in the past, been read from a 360° protractor on the flywheel illuminated by an ignition-fired stroboscopic light. A few years ago the G. M. Proving Grounds, the Laboratories, and other groups developed an electronic spark advance indicator. These spark advance indicators are now commercially available and are being built in a form suitable for dynamometer use. A spark pickup at the engine is connected by simply threading the spark plug lead through the pickup. The reference angle is secured by means of a magnetic device and actuated by pins mounted in the flywheel. Tests show it to be reliable and accurate to about ± ½° crankshaft revolution. It can be arranged to read average spark advance on either a 6- or 8-cylinder engine, or to read the spark advance on a single cylinder.

Pressure and Vacuum

Most dynamometer tests require the measurement of intake and exhaust manifold pressure. These are conveniently read on manometers. By providing a three-tube manometer as standard equipment, one spare unit is available if needed. These are readable and accurate to ± 1/20 inch of the fluid used.

Pressure gages are provided for oil pressure, air pressure, etc. Provision is made for five of these gages in the standard console, and more can be added if necessary. They are accurate to ± 1%.

Temperatures

Temperature measurements are made with iron-constantan thermocouples and a 0 to 600° F automatic indicating potentiometer with a 24-point push-button selector. These instruments are guaranteed to be calibrated within ± 0.2% of the industrial iron-constantan temperature-emf curve. Commercial thermocouple wire is guaranteed to produce an emf within ± 4F° or ¾%, whichever is

greater. Normally, this would mean over-all errors of ± 1% or less.

Atmospheric Pressure and Humidity

A mercurial barometer and a wet-and-dry-bulb hygrometer are used to give atmospheric data. The barometer can be read to ± 0.001 inch of mercury; reproducibility between operators is not this good. An accuracy of ± 1% relative humidity in the center of the range of a wet-and-dry-bulb hygrometer is claimed. Errors may rise to ± 4% at the extremes of the range.

Air Consumption

Air flow is not regularly measured in all engine test work. In order to improve the accuracy of calibrating air-flow equipment (such as the round-edged orifices commonly used at General Motors) a new type of displacement tank has been developed. Using orifices calibrated with this tank, it is possible to attain an accuracy of ± ½% under ideal conditions. In engine work, where pulsations occur, such accuracy cannot yet be expected.

In some dynamometer rooms the orifices may be installed at the engine bedplate. If conditioning of the engine air is required, the equipment may be installed in the basement. In other cases, where air flow measurements are made only occasionally, a portable pump with orifice tank may be used.

Mixture Ratio

Measurement of this quantity is becoming increasingly important. Mixture ratio may be measured by metering the fuel and air using methods indicated above. A more common method is to analyze the exhaust gas. The most basic instrument for the latter purpose is the Orsat analyzer, which uses the principle of selective gas absorption in liquids. An Orsat analysis requires several minutes of an operator's time, it must be located close to the engine in order to avoid long gas-sampling lines, and is subject to errors unless carried out by a skilled operator.

Recently, a conduction-type gas analyzer has become popular in the Laboratories. To give accurate absolute values of mixture ratio, it must be calibrated frequently (at least twice a day) against an Orsat. However, it is generally not used for absolute determinations but, rather, to detect changes in mixture ratio. It might be considered as an alternate to an instantaneous gasoline flowmeter because it can detect small changes in fuel delivery when the air consumption is constant. A new type of gas analyzer, working on an acoustic resonance principle, will read either the rich or the lean side with an accuracy equal to or surpassing any of the other methods. However, it is complicated, large, and expensive.

The Console

Consultation with engineers and dynamometer operators proved particularly valuable while designing the console. It appeared advisable to build the console in such a way that it would handle only the "standard" instruments discussed previously. Changes in these instruments would then be handled separately.

Voltage Supply For Ignition Primaries

A great deal of trouble was experienced in the past with a central 6-volt supply. As a result, every cell is now supplied with a storage battery mounted on the bedplate close to the engine. Where the engine is equipped with a generator, the battery may be charged with this generator through a suitable voltage regulator. However, since our experimental engines are frequently not so equipped, a battery charger is provided for each cell. After experimenting with commercial and special chargers, a unit was designed using a magnetic amplifier suitable for either 6- or 12-volt use.

Operator Training

Operating personnel should have a comprehensive understanding of the equipment if they are to exploit its full possibilities. A training course was presented consisting of fourteen two-hour class periods together with supervised individual demonstration and practice. About 250 people took this course in order that they might be able to use this equipment, maintain it, and interpret the data to the best advantage.

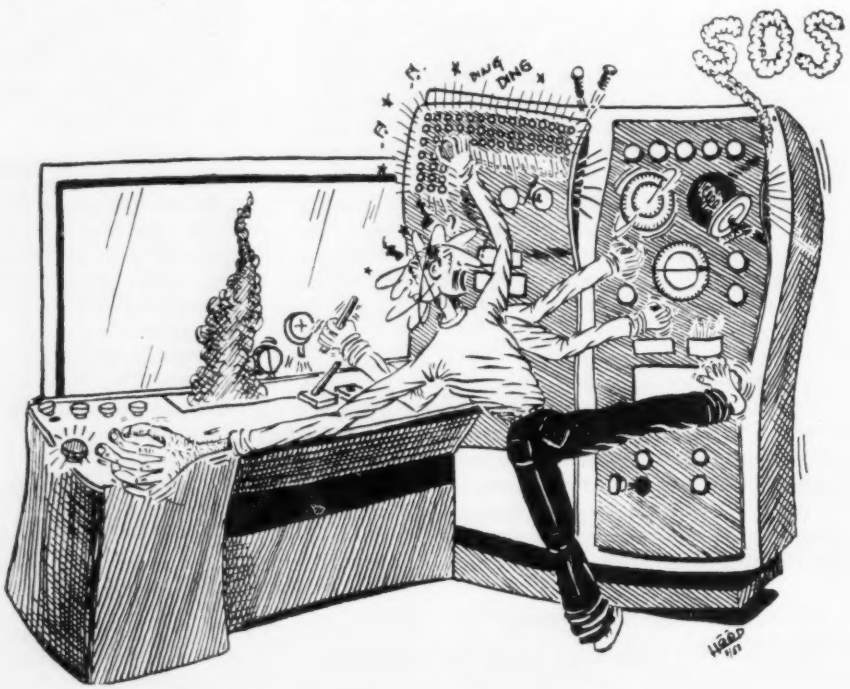


Fig. 2. Dynamometer operator taking his final exam.

Maintaining the Automated Plant

Annual industrial maintenance bill is $10 billion—and rising at a rate of $1 billion per year, largely because of automation. The automated Cleveland Engine Plant #1 of Ford Motor Company reports new approaches to the problem with decentralized maintenance, an IBM maintenance cost-control system, and use of JIC standards.

N. K. CONRAD
Ford Motor Company

WITH this new tool "automation" used by our manufacturing departments, a new method of "productive maintenance" must be employed.

Decentralizing Maintenance Activities

In the past, maintenance headquarters were located in one central area with most of the trouble calls coming to that point. Experience soon showed this to be costly. We found our skilled trades demanding a higher degree of versatility than we could acquire without more years of experience and training—due to the complexity of the equipment. We also found that the waiting period from the time the equipment went down to the time the repairman reached the scene was excessive. Therefore, instead of having one central shop trying to service this million-square-foot plant, we have divided our plant into five "productive maintenance" areas.

Each area has one man responsible for all the maintenance of that area over a 24-hr period. He in turn has foremen on each shift responsible to him. Hourly workers also are assigned to each specific area.

In the past it has always been a great problem to analyze maintenance costs accurately. Vast sums of money have been expended to keep machinery and equipment in operating condition; but, at no time was it ever possible to determine exactly how much any one particular job did cost. Thus it was deemed advisable to apply the benefits of an IBM installation to this phase of plant operating costs.

With this IBM installation, maintenance data on any machine, by trade, for any period of time, can be obtained at a moment's notice. To get this system in operation, many meetings were held with the plant manager and controller, comparing systems of cost control.

New Department Established

After a final decision was made on a feasible plan of practical cost control, we established our new department with a cost accountant for its supervisor and two clerks for maintaining proper flow of cost information.

The first and most important job was getting proper information for recording. It was decided to use a form on which an hourly worker filled in the time and nature of any job taking ½ hr or more; anything less than this is considered routine and is covered by a blanket general charge number at the end of the day. This newly created form is then signed by the foreman and used in filling out his time sheet. Each piece of machinery and equipment has an assigned accounting number painted on it. Each trade classification has a list of downtime reasons assigned with a code number to cover each reason. Then, to cover complete cost of repairs, each stock requisition written must have the machine or equipment number on it before being honored by the crib attendant.

All time sheets, hourly forms and requisitions must pass through our *Cost Control Unit* for complete review. This information is then dispatched to the IBM section where the report is prepared for our machine cost-record posting.

This information in turn can be used for highlighting recurring weaknesses of any machine or equipment, or cost of operating any machinery by unit or department.

Here are some examples of cost control:

(a) Every week a detailed maintenance cost report is issued to each area, making it possible for production and maintenance personnel to check and compare costs of their particular area.

(b) Cost of a rebuild or a troublesome job can be determined in detail simply by a telephone call.

(c) The weekly cost and year to date cost of the equipment having the highest cost for that week is issued to the plant manager and each department manager on a weekly basis.

JIC Standards Program

Another important factor is the use of the *joint industry conference* (JIC) standards, which is a collection of sound engineering and installation practices. These standards provide detailed specifications for the application of electrical, hydraulic, lubrication and pneumatic apparatus to industrial equipment. They are the result of joint action among automobile manufacturers, equipment builders, and associations in those fields.

The standards developed were based on logical systems of identification, greater accessibility of components, and better protection from contamination and hazards; and have resulted in more efficient and safer operation of machines and equipment. They include safety, identification of apparatus and wiring, accessibility for maintenance, complete wiring diagrams, sequence of operation, stock lists, standardization of oil reservoirs and power units, etc.

Conclusion

Our maintenance program approach has changed completely over a comparatively short period of time. Methods that formerly were desirable are now mandatory. "Productive maintenance" planning has had to keep pace with the new advanced techniques of manufacturing. In our opinion, our current installations are the most advanced type to be found anywhere.

Abstracts from paper presented at the ASME Semi-annual Meeting, Boston, Mass., June 19-23, 1955

Instrumentation for

HEAT-RATE TESTING

One-percent difference in turbine heat rate for a 165,000-kw steam turbine represents a fuel cost of $35,000. Standard power-plant instruments are shown to differ from high-accuracy code-recommended instrumentation by as much as 5.5% in heat-rate measurement.

PAUL MATTHEW
Pacific Gas & Electric Co.

FOR high-pressure, high-temperature large-capacity steam turbines installed in power plants, there is a need for high-accuracy heat-rate testing. Initially, this accurate testing is necessary for comparing the actual performance of equipment with the manufacturer's guarantees. Secondly, accurate testing is desirable for the periodic checks necessary in determining incremental loading schedules and equipment condition.

To illustrate the inaccuracies of standard power plant instrumentation, it is perhaps best to point out the differences between plant instrumentation and standard heat-rate test equipment during a series of actual turbine heat-rate tests. This series of tests was selected as a good example of the maximum effect of errors or deviations in plant instrumentation as compared with special test equipment. Normally, we would expect some of the deviations to be compensating by affecting the heat rate in opposite directions. However, it is possible to have deviations in one direction only, making the combined error rather large. The unit tested was completed in 1954 and is a tandem-compound, triple-flow, 3600-rpm, reheat machine with a normal operating capability of 165,000 kw (Fig. 1). Initial operating conditions are 1800 psig and 1000 F with reheat to 1000 F. The cycle is conventional for reheat units with regenerative feedwater heating.

Test Methods and Equipment

Since the standard method of determining the turbine heat rate for this type of cycle is to divide the total heat input by the power output, it is readily apparent that the most critical points of measurement, except power output, are in the high-pressure, high-temperature zone of the cycle. Specifically, as shown in Fig. 1, these critical points are: Feedwater entering the boiler, main steam to the turbine throttle, high-pressure turbine exhaust, intermediate-pressure turbine inlet, boiler feed pump suction, boiler feed pump discharge, and generator power output. From measurements taken at these points, the actual test heat rate may be obtained. To correct this heat rate to design conditions, other measurements such as condensate back-pressure and reheat pressure-drop are necessary.

As shown in Table 1, the special test equipment consisted for the most part of high-accuracy Code-recommended instrumentation whereas the permanent equipment is that normally installed as standard power-plant instrumentation.

The tests consisted of a series of two-hour runs at five turbine valve points. Data presented in this paper are based on the average deviation between plant instruments and special test equipment for the series of five tests.

Error Magnitudes

In Table II, the expected discrepancy and the actual average percent difference between test equipment and plant instrumentation for key measurements are shown along with the effect of the actual percent difference on calculated heat rate. The expected discrepancy is based on manufacturers' guarantees, ASME Code requirements, and past experience in checking plant instrumentation on similar tests.

Table I
Comparison of Types of Instrumentation

Measurement	Heat Rate Test Equipment	Standard Plant Equipment
Flow	Calibrated flow nozzle in special pipe section with mercury manometers	Standard flow nozzles or orifices connected to flow meters
Temperature	Calibrated thermocouples with high accuracy potentiometer	Resistance elements and industrial thermometers
Pressure		
30 to 2000 PSIG.	Dead weight gages	Calibrated Bourdon tube gages
30" HG. to 30 PSIG.	Mercury Manometers	Calibrated Bourdon tube gages
Condenser Pressure	Zimmerli Absolute pressure gage	Vacuum column and barometer
Power	Calibrated watthour meter	Station watthour meter

Abstracted from ISA Preprint 55-16-1, presented at ISA National Conference, Los Angeles, Sept. 12-16, 1955. Copies available from ISA, 1319 Allegheny Ave., Pittsburgh 33, Pa.

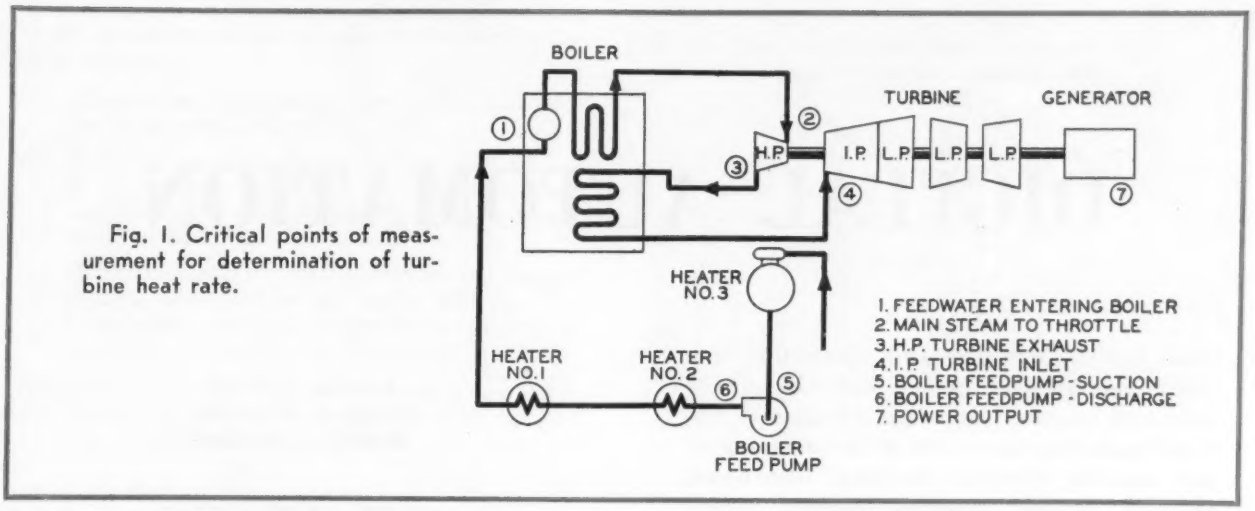


Fig. 1. Critical points of measurement for determination of turbine heat rate.

Values of effect on heat rate are based on the maximum load point. Percentage differences were substantially the same on all test load points. In analyzing these various factors, it is readily apparent that the two most critical, and in this case two of the most inaccurate measurements, were cycle flow and power output. The error due to these two measurements alone is over 3.5% and considerably greater than our expected discrepancy of 1.5%. The average difference of measurement of high-temperature steam exceeded the expected by approximately three to one, accounting for almost 2% difference in calculated heat rate. Low-temperature and all pressure measurements were within their expected deviations. The overall difference in calculated heat rate at maximum load between the two installations of test equipment, based on values of average difference, is over 5%. Actual difference in calculated heat rate by the two methods of measurement varied from 2.5 to 5.5% for the five points with a load weighted average difference of more than 4%. This exceeds our expected deviation of ± 1.5% (based on the square root of the sum of the squares of the individual expected discrepancies).

These percentage figures become very important when evaluated as an annual fuel cost. Example: A difference in turbine heat rate of 1% for a machine of this capacity operating with an average annual load factor of 90% would represent an annual fuel cost of more than $35,000. This points out forcefully the need for accurate heat-rate testing to establish incremental loading schedules and indexes of equipment performance.

Table II

Discrepancies Between Standard Plant and Special Heat Rate Instrumentation

Measurement	Expected Discrepancy	Actual* Average Difference	Effect of Average** Difference on Calculate Turbine Heat Rate—%
Power output	±0.5%	−1.1%	+1.1
Cycle flow	±1.0%	+2.5%	+2.5
Main steam temp.	±0.5%	+1.7%	+1.0
H.P. exhaust temp.	±1.0%	−0.8%	+0.3
Reheat steam temp.	±0.5%	+1.3%	+0.8
Final feedwater temp.	±1.0%	−0.3%	+0.1
Throttle pressure	±0.5%	−0.3%	+0.1
Reheat pressure drop	±5.0 PSI	−5.0 PSI	+0.1
Condenser back pressure	±0.10" HG.	−0.05" HG.	+0.1

* Plus (+) Denotes a value greater than observed by special instrumentation.
** Plus (+) Denotes a higher calculated heat rate.

Error Sources

In analyzing the results of this series of tests, we find that errors for the most part are due to instrument inaccuracy. On the other hand, errors chargeable to plant arrangement include such items as the location of watthour meters, pressure measurement taps, and thermometer wells. For example, the station watthour meters are located several hundred feet from the potential drop in addition to the abnormal burden on the leads. The voltage drop from the potential cell to the watthour meter was of the order of one volt, which would introduce an error of approximately 1%. By reducing the distance, increasing the wire size, and decreasing the burden, the difficulties in this metering system can be improved.

Fluid flow measurement appears to be the weakest link in standard plant instrumentation. The normal guarantee by manufacturers is ± 2% for metering systems although our experience indicates agreement between meters to be in the order of ± 1% in the upper half of chart range. Of the four meters installed in the cycle at various points measuring condensate flow, feedwater flow, boiler steam flow and turbine steam flow, the average deviation from cycle flow determined by a calibrated flow nozzle ranged from −0.5 to + 2.5% with two indicating + 2.5% and one indicating + 1.5%. Nozzles installed in the steam lines are in special pipe sections located in straight pipe runs. We feel that additional precautions in manufacturing and refinements (such as polishing nozzle surfaces) should lower the probable error of flow measurement to ± 0.8%. Since the magnitude of error in heat rate is directly proportional to the error in flow measurement, it may even be worthwhile to calibrate flow nozzles associated with permanent plant equipment to reduce the probable error.

Greater accuracy of temperature measurement is necessary. Differences of 1.5% are far too large. Better calibration and closer manufacturing tolerances of primary elements may be required.

Pressure measurements as required for heat-rate testing are not as critical as flow or temperature measurement. In most instances, well-calibrated Bourdon-tube gages are satisfactory. For measuring condenser back pressure, a dependable absolute-pressure-measuring device is to be preferred to observation of the difference between a barometer and a vacuum column.

DIGITAL AUTOMATION

Most logical networks and computing machines use straight binary code. Here is a thorough introduction to binary number systems, including discussion of the meaning of any number system, decimal numbers, straight binary numbers, decimal binary number, trinary numbers, octonary numbers, binary-coded decimal numbers, and cyclic coded numbers. Of basic importance are the techniques for addition, subtraction, multiplication and division with binaries. Entire new fields of logical design problems open to the man who learns these simple techniques. This is part two in this series on digital automation.

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There is no substitute for homework and a little practice when learning how to count and add. Here are a few test items on the fundamentals of binary arithmetic. Work them out after reading this article! You will then be prepared for next month's discussion of the Diode Matrix, which becomes a powerful decision-making problem solver with binary technique. (Answers are at end of article.)

1. In the decimal system the radix is
   (a) 1
   (b) 2
   (c) 8
   (d) 10
2. In the binary system the radix is
   (a) 1
   (b) 2
   (c) 8
   (d) 10
3. Binary number 1101 is equivalent to decimal number
   (a) 3
   (b) 8
   (c) 13
   (d) 26
4. Binary number 111.011 is equivalent to decimal number
   (a) 7.011
   (b) 7.125
   (c) 7.375
   (d) 7.777
5. The binary sum of binary numbers 11,011 and 10,101 is
   (a) 11,111
   (b) 100,000
   (c) 110,000
   (d) 101,110
6. The complement of binary number 11,010 is
   (a) 00,101
   (b) 00,110
   (c) 11,011
   (d) 11,001
7. The complement of binary number 100,011 is
   (a) 011,101
   (b) 100,100
   (c) 011,100
   (d) 100,101
8. The binary product of 101 and 101 is
   (a) 10,001
   (b) 10,101
   (c) 11,001
   (d) 11,101
9. The division of binary 1100 by 0110 yields
   (a) 0010
   (b) 0001
   (c) 0011
   (d) 1000

CODE ARITHMETIC

Numbers

A NUMBERING system is simply an orderly system of marks used for making quantitative measurements or records. The most familiar system is the decimal system, which uses the ten marks (or Arabic numerals)—0, 1, 2, 3, 4, 5, 6, 7, 8, and 9.

This is not the only system of marks in use. Years ago the Mayan Indians used a five-mark system (which we call a quinary system). Their marks were not Arabic numerals. Another quinary system which does not use Arabic numerals is the familiar Roman numerical system which uses the five marks I, V, X, C, and M. (The Roman numeral system is actually a biquinary system in which symbols L, representing 50, and D, representing 500, are used instead of X and C at certain times.)

For computing and automation purposes, the decimal system is difficult to use. Therefore, most computers operate in a simple number system known as *binary code*. This chapter discusses number systems and the practical application of the binary system for the design of logical networks and computing machines.

Elements of a Number System

Whether or not a collection of marks is a true numbering system is determined by the method used to progress from one number to the next. For example, if we ask what number follows 467, most people recognize that it is 468. Similarly, we know that 10 follows 9; 500 follows 499; 7,856 follows 7,855. This we know from experience or education. But is there any reason for these successions of numbers?

There are two ways to figure out what number follows another in any given numbering system—by comparing against a known system, or by deducing the basic methodology used in advancing from one number to the next.

There is no method to the original choice of "marks" used in any numbering system. The reason that 7 follows 6 in our decimal Arabic system is only because of historical accident and chance involving the Arabic language. But in progressing from 9 to 10, an important and basic reasoning process is involved. What we did, knowingly or unknowingly, in progressing from 9 to 10 was the following:

1. We advanced the rightmost mark (9) back to the *first* number in the system of marks (0).

2. Then we advance one column left and advanced whatever mark was in this column (an implied 0) to the next mark in the system (1).

Now we have at our disposal a *method* for progressing from one number to the next number. Follow the instructions given here:

(1) Advance the rightmost number to the next number in the system (from 6 to 7, etc.)

(2) If the rightmost number is the last mark allowed in the system, change it to the first. Then move one column left and advance this to the next mark in the system.

(3) If this column to the left also uses the last number in the system (such as the number 499, 99, 399) follow step 2 until you reach a column where you *can* change the number to the next mark.

This is the method and also the criterion for a number system, irrespective of what numerals or marks are used and irrespective of how many marks are used in the system.

Let us see how the three rules set forth conform with our decimal system in handling the progression of numbers. To progress from 456 to the next number we use Rule 1 and find that the rightmost number is 6, which is immediately advanced to 7, thus giving us the number 457.

Now consider 589. We find that we must use Rule 2 because the rightmost number is the last number allowed in the decimal system. According to this rule we change this to the first mark in the number system, which is an 0. Then we move up to the next column and change the 8 to the next mark, which is a 9, and obtain 590. Thus 590 follows 589. Similarly, we can show that Rule 2 will handle the change from 479 to 480, 9 to 10, and so on.

The third rule is invoked in dealing with numbers such as 599 and 6999 where there is one or more 9's at the end of the number. To find the number following 599 using Rule 3, we change the rightmost 9 to a 0 and then *index*, or move one column left. This is also a 9 so we must change this also to a 0. The third column contains a 5 which we can change to a 6 and thus obtain the number 600. The number 6,999 requires that we change the three 9's to 0 and, finally, the 6 can be changed to a 7 to obtain the number 7000, which follows 6,999. We now have a *method* of finding by some means the succession of numbers in a numbering system.

Applying The Rules to Other Systems

Let us now apply these rules to a numbering system which is different from the decimal system. For comparison, we will use letters to represent quantities—and only four of them. Thus, we have the following list of four marks and their decimal equivalents:

0 1 2 3
a b c d

What number follows *bc*? Following the same set of rules, we find the rightmost mark is a *c*, which is not the last mark allowed. We advance this to a *d* and, therefore, the number *bd* follows *bc*.

What number follows *abcd?* Here the rightmost column uses the last mark *d*, so this must be changed to the first mark, which is *a*. The next column we advance to contains a *c*. This advanced to a *d* and we have the new number *abda* as the number following *abcd*. These alphabetic symbols can represent numbers easily converted into decimal numbers, but we will not take time to do this. Instead, we shall now consider the system used by most digital computers and digital control systems—straight binary code.

Table 2-1.—Decimal Numbers and Binary-Number Equivalents.

Decimal	*Pure Binary*
0	0 0 0 0
1	0 0 0 1
2	0 0 1 0
3	0 0 1 1
4	0 1 0 0
5	0 1 0 1
6	0 1 1 0
7	0 1 1 1
8	1 0 0 0
9	1 0 0 1
10	1 0 1 0

Straight Binary Code

Binary code uses only two marks. For convenience the marks chosen are the decimal marks 0 and 1. No other numbers are used in binary.

Let us ask, in binary, what number follows 110? The rightmost column is advanced to a 1 (by Rule 1) and we obtain 111. Similarly, 1011 follows the number 1010, and 11111 follows 11110.

Now let us use Rule 2 and find what follows the number 01. The rightmost column has a 1, which is advanced to the first mark 0. The column containing the 0 is advanced to a 1 and we find (this may appear surprising) that 10 follows 01.

Note that in binary all numbers can have *only* the two chosen marks. Numbers appear like this: 11101, 111011, 1101111, 1111111. If *any* other number or mark appears, something is in error because the only two admissible marks are the 0 and the 1. We could have used the letters *a* and *b* as the marks for binary, but this unconventional; computer engineers and mathematicians prefer to use the Arabic numerals 0 to 1. We shall follow this convention also. Applying the rules given, the decimal numbers from 0 to 10 are equivalent to the binary numbers 0 to 1010, as shown in Table 2-1.

Converting from Binary to Decimal

The question next arises: What does binary number 111011 (or any binary number) represent in our conventional decimal system?

If we were educated to think in binary numbers, we would recognize immediately, by experience, what these binary numbers represent. Unfortunately, we think in decimal and, therefore, it is necessary to convert binary numbers to our decimal system. In order to do this, let us examine what conventional decimal numbers genuinely represent.

Meaning of a Decimal Number

In the decimal system, we think in "tens." The number 49 means:

$$10 + 10 + 10 + 10 + 9 = 49.$$

This can be written more briefly as:

$$4(10) + 9(1) = 49$$

Or also as:

$$4(10^1) + 9(10^0) = 49$$

Table 2-2.—Powers of Common Number Systems.

2^0	= 1	8^0	= 1	10^0	= 1
2^1	= 2	8^1	= 8	10^1	= 10
2^2	= 4	8^2	= 64	10^2	= 100
2^3	= 8	8^3	= 512	10^3	= 1,000
2^4	= 16	8^4	= 4,096	10^4	= 10,000
2^5	= 32	8^5	= 32,768	10^5	= 100,000
2^6	= 64	8^6	= 262,144	10^6	= 1,000,000
2^7	= 128	8^7	= 2,097,152		
2^8	= 256	8^8	= 16,777,216		
2^9	= 512				
2^{10}	= 1,024				
2^{11}	= 2,048				
2^{12}	= 4,096				

Similarly, the number 2,345 really means:

$$2000 + 300 + 40 + 5 = 2{,}345$$

or

$$2(10^3) + 3(10^2) + 4(10^1) + 5(10^0) = 2{,}345.$$

Note that the number 10 appears to various powers. Hence we say that *all* numbers are obtained by using the total number of marks in the system (called the radix) raised to various powers. Note also that the radix is raised to higher and higher powers as we move to the left in columns, or index to the left.

Note that numbers such as 43.21 can be represented by:

$$4\ (10^1) + 3\ (10^0) + 2\ (10^{-1}) + 1 \times (10^{-2}) =$$
$$40 + 3 + 0.2 + 0.01 = 43.21$$

Note that as we move right from the decimal point, the 10's are raised to successively higher powers of negative numbers. In every case, the number raised is the *radix,* which is the total number of distinct marks in the number system used. In the decimal system there are ten marks; hence the radix is 10. In the binary system there are two marks; hence the radix is 2.

Table 2-3.—Radix of Common Number Systems

System	*Marks Commonly Used*	*Radix*
Decimal	0, 1, 2, 3, 4, 5, 6, 7, 8, 9	10
Binary	0, 1	2
Trinary	0, 1, 2	3
Octal	0, 1, 2, 3, 4, 5, 6, 7	8

Conversion of Binaries

Let us use this convention for finding what decimal number the binary code 1101 represents. As only two marks are used, the radix is the number 2.

$$\begin{aligned} 1101 &= 1(2^3) + 1(2^2) + 0(2^1) + 1(2^0) \\ &= 1(8) + 1(4) + 0(2) + 1(1) \\ &= 8 + 4 + 1 \\ &= 13 \end{aligned}$$

Thus 1101 in binary code is the same as the number 13 in decimal numbers. Any binary number has its decimal equivalent, as shown in table 2-1. It should also be noted that in converting from binary to decimal, we use the number 2 raised to various powers. Table 2-2 shows some various powers of 2, which can be used for determining the decimal equivalents of various binary numbers.

Decimal Binary Numbers

Decimal binary numbers are binary numbers with a decimal point, such as 11.01. These, too, can be converted in the same way. Thus 11.01 can be written as:

$$1(2^1) + 1(2^0) + 0(2^{-1}) + 1(2^{-2}) =$$
$$2 + 1 + 0 + 0.25 = 3.25$$

Therefore, binary number 11.01 is identical with decimal number 3.25.

Computers and digital systems generally work in binary code, for reasons which will become evident shortly. Hence complete understanding and familiarity with binary coded numbers (and of the decimal numbers they represent) is important.

For additional practice, the *trinary number system* can be investigated for a moment. Here we use three distinct marks (0, 1, 2), and the radix (number of marks) is then 3. Numbers such as 01112, 2101, 110 and 2222 are numbers in this system. Let us set down the system marks.

Decimal number	0 1 2 3 etc.
Trinary mark	0 1 2 - No others.

Let us take the trinary number 2101 and find what its decimal equivalent is. Using 3 as radix, we obtain:

$$2(3^3) + 1(3^2) + 0(3^1) + 1(3^0) =$$
$$2(27) + 1(9) + 0(3) + 1(1) = 64,$$

the decimal equivalent for 2101 in trinary.

It is important to know in what system a number is being given. For example, 111 in decimal is 111; 111 in binary is the decimal number 7; 111 in trinary is the decimal number 13.

Addition with Binary Numbers

Binary is perhaps the easiest set of numbers in which to perform arithmetic; in fact, *this is the reason why the binary system is used in computers and logical networks.* Addition is particularly simple.

In decimal addition, we are forced to remember that 9 plus 8 are 17; that 5 plus 6 are 11; and so on and on. In binary, we need remember only the following two simple rules:

1. 0 plus 1 is 1
2. 1 plus 1 is 0 and carry a 1 to next column left.

With these two rules we can perform addition. Thus, if we are to add 10 and 11:

$$\begin{array}{r} 10 \\ 11 \\ \hline 1 \\ 0 \text{ carry 1 left} \\ 1 \quad \text{the carry} \\ \hline 101 \end{array}$$

Let us see if this is consistent with decimal addition; 10 is binary for the decimal number 2, and 11 is binary for the decimal number 3. The sum of these should give decimal 5. The sum has been determined as 101 and thus

$$101 = 1(2^2) + 0(2^1) + 1(2^0) = 5.$$

The two results check.

As another example, let us add 27 (or binary 11011) and 13 (or binary 1101):

$$
\begin{array}{rl}
11011 = 27 & \\
+\ \underline{1101} = \underline{13} & \\
\quad 0 & \text{carry 1} \\
\quad\ 0 & \text{carry 1} \\
\quad\ 0 & \text{carry 1} \\
\quad 1 & \text{carry 1} \\
\quad 0 & \text{carry 1} \\
\underline{1} & \text{the carry} \\
101000 & \text{is the resultant number.}
\end{array}
$$

Converting this to decimal: $101000 = 1(2^5) + 1(2^3) = 32 + 8$.

The sum is 40—and we check results.

Advantage of Binary

The advantage of binary is that we deal with only the simplest of rules. In decimal, although it is possible to determine the sum of 8 and 9 by logic and reasoning, we are forced to commit this to memory because the logic is too involved and time consuming. (Computer engineers develop pretty much the same technique of comitting binary additions to memory.) However, the *process* of addition with binaries is reduced to two simple rules (In many backward countries, this type of addition is taught the illiterate because of its simplicity.) The computer, which itself is a highly illiterate device, works fastest and most easily in binary because only two easily-performed functions are required for the two basic rules.

Subtraction

Subtraction in binary code is more involved than addition, and requires using a technique known as *complementing*. Complementing means adding that which completes the number. For example, when dealing with angles, the complement of an angle is that angle which, when added to the original angle, makes an angle of 90°. Since the complement of a number is obtained by subtracting it from some reference number, the process of subtraction of a number is seen to be equivalent to the *addition* of its complement. Complementing is a technique for conversion of the subtraction process to one of addition.

If a number is complemented, the complement is used to *subtract by addition*. Let us see how this works with a conventional decimal number. Let us subtract 32 from 48. Using a reference of 100, obtain the complement of 32, which is 100 minus 32, or 68. Now, to subtract 32 from 48, let us instead add the complement (68) to 48:

48 plus 68 equals 116.

If we discard the reference (100) by crossing off the first 1, the answer is 16, which is the correct answer. Thus we see that subtraction can be performed by the addition of the complement, if the reference is discarded. Note that the reference number appears in the n+1 column if a number with n digits is being complemented.

Complementing A Binary Number

The complement of a binary number is obtained in the folowing manner: To complement a binary number, *change each* 0 *to a* 1 *and each* 1 *to a* 0—*then add a* 1 *in the rightmost column.*

For example, the complement of the binary number 1111 is obtained by changing this number to 0000 and then adding a 1 to yield 0001, which is the complement of 1111. The complement of 11010 is 00110 as shown:

$$
\begin{array}{ll}
11010 & \\
00101 & \text{change} \\
\quad 1 & \text{add a 1} \\
\hline
00110 &
\end{array}
$$

The binary complement is used to *subtract by addition* in the following way:
Let us subtract 0100 (or decimal number 4) from 1010 (or decimal number 10)

$$
\begin{array}{rl}
1010 = & 10 \\
-\underline{0100} = & -\underline{4}
\end{array}
$$

The number to be subtracted (0100) is first complemented. Doing this, we obtain 1100 as the complement. This is now added to 1010:

$$
\begin{array}{r}
1010 \\
\underline{1100} \\
10110.
\end{array}
$$

The leftover number is a 1, which is discarded. *It indicates that the answer is positive.* The answer is +0110, which is equivalent to decimal number 6. This agrees with the decimal subtraction of 10 − 4.

Note that the first digit, the leftmost one (in this case a 1) is neglected and indicates only a positive sign. The number left *after* the 1 is discarded is the actual binary number for the result.

Subtraction with a Negative Result

Now let us perform a subtraction that results in a negative number, instead of a positive result. Let us subtract 8 from 3, to yield −5. Let us perform this operation in binary and decimal

$$
\begin{array}{rr}
0011 & 3 \\
-\underline{1000} & -\underline{8}
\end{array}
$$

We first complement the number being subtracted (1000) to obtain 1000. Here the complement is the same as the number—a coincidence. Now add the complement:

$$
\begin{array}{r}
0011 \\
+1000 \\
\hline
1011
\end{array}
$$

We can write this with the implied 0 in the fifth column as 01011 (because the reference is always in the n+1 column). This extra column on the left has a 0, whereas in the previous example this extra column developed a 1 (which indicated a plus sign). The 0 shows that the answer is negative. It also shows that the result must be again complemented. The complement of the result (1011) becomes 0101. This is binary for the decimal number 5, and with the minus sign the answer is −0101, which is −5. This checks with the decimal result obtained.

The process of subtraction thus comprises the following set of operational procedures:

1. Complement the number to be subtracted.
2. Add the complement to the positive number.
3. If the *extra column* develops a 1, discard it and replace it with a plus sign; the answer is then given.
4. If the *extra column* contains an implied 0, it is replaced by a negative sign and the result is complemented; the answer is then given.

In short, whenever a negative number appears, it is immediately complemented. The process of subtraction, then, is essentially one of *complementing* and *addition*. This is particularly convenient in computers because the same mechanism to perform addition can be used to perform both subtraction and addition. It will be shown that complementing can be accomplished simply by electronic technique.

Addition and subtraction of binaries have been discussed; the arithmetic operations remaining are multiplication and division.

Multiplication

Binary multiplication removes the necessity for multiplication tables because of its complete simplicity. It is essentially a process of addition and indexing, or moving progressively left. Let us multiply the binary numbers 011 x 110.

011 is binary for the number 3, and 110 is binary for the number 6. The result should yield the number 18. Multiplication is performed with only the following two rules:

Rule 1: 1 x 0 is 0
Rule 2: 1 x 1 is 1

The conventional method of indexing, or moving left, with each multiplication is preserved. Using these two rules we multiply as follows:

$$\begin{array}{r} 011 \\ \times\ 110 \\ \hline 000 \\ 011 \\ \underline{011} \end{array}$$

The addition of these quantities yields the result:

$$\begin{array}{r} 000 \\ 011 \\ \underline{011} \\ 10010 \end{array}$$

Converting this number to its decimal equivalent: $1\ (2^4) + 1\ (2^1) = 18$. This agrees with the decimal calculation.

As an additional example, let us perform the multiplication of some larger numbers. Multiply 11011 (or 27) by 11101 (or 29). The answer should be the binary number equivalent of the decimal (27) (29) or 783. This multiplication is done as follows:

$$\begin{array}{r} 11011 \\ 11101 \\ \hline 11011 \\ 00000 \\ 11011 \\ 11011 \\ \underline{11011} \\ 1100001111 \end{array}$$

This has for its decimal equivalent the number 783. It can be seen that the multiplication of binary numbers involves only the process of setting down the number in its proper position (if we are multiplying by a 1) or omitting it (if we are multiplying the number by a 0). The result is a collection of binary numbers to be *added* to give the result. Multiplication then, is merely an orderly or prescribed manner of addition, without requiring any knowledge or basic mechanism beyond that of addition. This, too, is particularly convenient in dealing with computing machines where this can be accomplished electronically in simple ways.

Division

Division can be carried out much like decimal division, but considerably simplified. It is a matter of finding out whether the divisor goes into the number or is smaller than the number. In the former, a 1 is carried into the divident, if not a 0. For example, let us divide 1001 or decimal 9) by 0100 (or decimal 4). The answer should be 2.25.

To perform the operation in binary we carry the process much like decimal:

$$\begin{array}{r} \quad 10.01 \\ 0100\overline{)\ 1001.00} \\ \quad 100 \\ \hline \quad 000100 \\ \quad\ \ 100 \\ \hline \end{array}$$

The quotient can be converted into its decimal equivalent by the usual process:

$$1(2^1) + 1(2^{-2}) = 2.25$$

Combined Arithmetic Operations

Combinations of these four basic arithmetic processes follow precisely the rules of decimal arithmetic; commutative, distributive, and associative laws apply as in ordinary arithmetic. That is to say, we perform the combined operations in the same order and manner in which the decimal computations would be made. At first sight the numbers appear strange in binary, but the procedures are precisely the ones outlined.

For example, let us perform the following operations

$$\frac{0011\ (110 - 011)}{100} \quad \text{or} \quad \frac{3(6 - 3)}{4}$$

The first step is to perform the subtraction indicated. This requires complementing the number 011 to yield 101.

The next step is to add the complement

$$\begin{array}{r} 110 \\ 101 \\ \hline 1011 \end{array}$$

The carried column indicates a 1, or positive number, which is discarded, leaving the number 011. The next step can be either the division or the multiplication. We will perform the multiplication first:

$$\begin{array}{r} 011 \\ \times\ 011 \\ \hline 011 \\ 011 \\ \hline 1001 \end{array}$$

The remaining operation is the division 1001/100:

$$\begin{array}{r} \quad 10.01 \\ 100\overline{)\ 1001.00} \\ \quad 100 \\ \hline \quad 000100 \end{array}$$

This is the same division performed previously, and we have seen that the answer is 2.25.

As a check we can rewrite the original number in decimal

$$\frac{0011\ (110-011)}{100} = \frac{3\ (6-3)}{4} = 2.25$$

and we see that the results check.

Alternate Representation

The symbols used most often in binary operations are the Arabic numbers 1 and 0. This is purely a convenience. The two symbols could be represented by any two letters, or any two words. For example, the Arabic number 1 could be represented by the word "ON" and the number 0 could be represented by the word "OFF." This becomes convenient when switches or any ON-OFF devices are used to represent the conditions 1 and 0. For example, the binary number 1101 could be given as:

1101 = ON ON OFF ON

The two basic rules for addition become:

Rule 1: (1+0 =1): ON + OFF = ON
Rule 2: (1+1 = 0 carry 1): ON + ON = OFF carry ON

Let us add 1101 and 011 in word code:

```
 ON ON OFF ON
    OFF  ON ON
 ---------------
          OFF    carry ON
       OFF       carry ON
    OFF          carry ON
 OFF             carry ON
ON
 ---------------
ON OFF OFF OFF OFF
```

This is equivalent to ON (2^4), or $1(2^4)$, or 16.

To check, note that 1101 is 13, and 011 is 3; the sum is 16.

This ON-OFF representation of the two binary conditions is the basis for all digital computational operations and digital control devices.

Binary and Octonary Conversion

Another code which is of value is the *octonary code,* which uses eight distinct marks. In this system the marks used, again for convenience only, are Arabic numerals:

0, 1, 2, 3, 4, 5, 6, and 7.

The advantage in using octonary is to be found in interpreting binary numbers. That is, use of octonary permits converting from binary to decimal with minimum mental effort, as is shown by the following:

Let us assume that we have sufficient facility with binaries so that we can immediately recognize the binary numbers from 0 to 7 in decimal. In other words we can look at binary 111 and know it is 7, and that 011 is binary for 3, and so on for all numbers up to 7. Let us now take the binary number 0110111 and break it up into groups of three binary numbers (called *bits* for short):

000 110 111.

Looking at each group, no group being larger than decimal 7 (111), we can immediately write this down in octonary form:

0 6 7

In other words, by taking groups of three we can, with only little practice, convert binary to octonary by examination. Thus we have binary 0110111 equals 0 6 7 in octonary. Now convert the octonary to decimal, remembering that the radix is the number 8.

$0(8^2) + 6(8^1) + 7(8^0) = 55$

This is a rapid computation as compared with the direct conversion from binary to decimal, which is as follows:

$1(2^5) + 1(2^4) + 0(2^3) + 1(2^2) + 1(2^1) + 1(2^0) = 55$

The convenience lies in having the ability to take the binary numbers from 000 to 111 (decimal 0 to 7) and writing them down directly. Further, instead of adding five terms to obtain the answer (as was need for the conversion from binary to decimal), only two terms had to be added to convert from octonary to decimal. Thus the conversion from octonary to decimal proceeds simply and with a minimal number of operations.

Binary-Coded Decimal

Another system is used in some machines to aid in reading out the result (the actual computaitons taking place in straight binary code). This is the binary-coded decimal scheme.

The binary-coded decimal system uses binary devices to indicate decimal numbers. Binary devices change state on every signal and hence respond in the series 0, 1, 2, 4, 8, 16, etc. Any number between 0 and 10 can be represented by four such binary devices (indicating 1, 2, 4, and 8) as follows:

0 = 0
1 = 1
2 = 2
3 = 2 + 1
4 = 4
5 = 4 + 1
6 = 4 + 2
7 = 4 + 2 + 1
8 = 8
9 = 8 + 1
10 = 8 +2 carry 1 to next row.

Each column of numbers on the binary-coded decimal device consists of four binary devices, as shown in Fig. 2-1. Column 1 can represent all numbers from 0-9; column two, 10-90; column three, 100—900; etc. Thus any decimal number can be read out of these binary devices, by using the binary-coded decimal notation of Fig. 2-1. In Fig. 2-1 a binary-coded decimal device is shown indicating the decimal number 863 in binary-coded decimal technique.

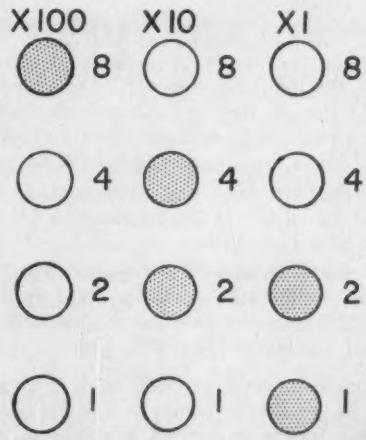


Fig. 2-1. Binary-coded decimal readout devices use rows of lights indicating 1, 2, 4 and 8. Shown is representation of the decimal number 863 in binary-coded decimal.

Cyclic Coding

In addition to the straight binary and trinary codes discussed, use is sometimes made of special codings derived from the binary coding. These codes have certain practical advantages in applications to computing devices and electronic converters. The most widely used of these is known as a *cyclic coding*, and is derived from the binary code.

Cyclic coding has the advantage of changing only one bit in going from one number to the next succeeding number. For example, in straight binary progressing from 000 to 001 we find that only one bit changes. However, if we go from 0111 to the next binary number, which is 1000, we find four bits changing simultaneously. With a cyclic code, no matter what the number is, the next number is different in only a single bit.

Cyclic coding can be obtained from the binary in a straightforward manner. To progress from the number in binary to its cyclic equivalent, *we add the binary number to itself without carrying; before adding, the number is indexed one place to the right.* Thus, if we go from binary 111 (which is decimal 7) to the cyclic number code for 7 we perform the following addition:

$$\begin{array}{r} 111 \\ 11(1) \\ \hline 100 \end{array}$$

To obtain the cyclic code for decimal 13, we first find the binary, which is 1101. Then the following non-carrying addition, as above, is performed:

$$\begin{array}{r} 1101 \\ 110 \\ \hline 1011 \end{array}$$

Thus 1011 is cyclic code for decimal number 13. Examining Table 2-4, we find that as we progress from one cyclic number to the next; one and only one bit changes at a time.

To find the decimal number from a given cyclic number, we pass backward through the binary number. The binary number is obtained in the following manner:

First add the number of 1's in the cyclic number without carrying; this represents the least-significant bit (the last digit) in the binary number. Add this to the least-significant bit of the cyclic (without carrying) to obtain the next most significant (2nd) bit of the binary number. Add the 2nd most significant bits of the binary number and the cyclic number to obtain the 3rd. Continue this process *without carrying* until all of the bits are used. This is the binary number.

For example, to progress from cyclic code 13, which is 1011:

1. We add the 1's without carrying to obtain 1.
2. Add this to the cyclic number's least-significant bit (which is 1) without carrying to obtain 0, the 2nd bit in the binary number. We now have 0001.
3. To the 2nd binary bit obtained (a 0) add the 2nd bit of the cyclic number (a 1) to obtain 1. We now have 0101.
4. To the 1 obtained in 3 above, which is the 3rd most significant bit, we add the third bit of the cyclic number (a 0) to obtain 1. We now have 1101, which is binary for 13.

Thus a code developed which is derived from binary and which has certain advantages, and yet each and every code number stands in distinct relationship to a decimal number.

Excess 3 Binary

A code that makes subtraction easier is the Excess 3 Notation, shown in Table 2-4. Note that it is the same as pure binary except that each number is the binary number plus three (011). Note that in Excess 3 Binary, the 0 and 9 are identical opposites—that is, the 0 replaces the 1, and the 1 replaces each 0. Similarly for the numbers 3 and 6, 2 and 7, 4 and 5. In other words, 9 minus any number is the same as the number except for the interchanging of 0's and 1's. This facilitates complementing and subtraction.

Table 2-4.—Comparison of Pure Binary with Cyclic, 1-2-4-7, and Excess 3 codes.

Decimal	*Pure Binary*	*Cyclic*	1, 2, 4, 7	*Excess* 3
0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 1 1 ←
1	0 0 0 1	0 0 0 1	0 0 0 1	0 1 0 0
2	0 0 1 0	0 0 1 1	0 0 1 0	0 1 0 1
3	0 0 1 1	0 0 1 0	0 0 1 1	0 1 1 0 ←
4	0 1 0 0	0 1 1 0	0 1 0 0	0 1 1 1
5	0 1 0 1	0 1 1 1	0 1 0 1	1 0 0 0
6	0 1 1 0	0 1 0 1	0 1 1 0	1 0 0 1 ←
7	0 1 1 1	0 1 0 0	1 0 0 0	1 0 1 0
8	1 0 0 0	1 1 0 0	1 0 0 1	1 0 1 1
9	1 0 0 1	1 1 0 1	1 0 1 0	1 1 0 0 ←

1, 2, 4, 7 System

The 1, 2, 4, 7 system (or 7 4 2 1 system) has the advantage that only two 1's are used to express any number. Note that after number 6 is reached, another column is used to attain number 7, rather than using three 1's. Hence the code is called 1, 2, 4, 7 to distinguish it from the conventional binary code, which is a 1, 2, 4, 8 code.

Floating Decimal Point

Floating decimal point is a short cut that can be used for either longhand or computer arithmetic. This involves writing the number with significant figures times a multiplier expressed exponentially. For example, to multiply 1200 x 1200, we can multiply $(1.2)(10^3)$ x $(1.2)(10^3)$, and obtain 1.44 (10^6), which is 1,440,000. This "floating decimal point" technique involves multiplying all numbers other than 10 and adding the exponents of 10. It saves the adding up of a lot of columns, as in conventional multiplication.

Decimal Operation

Desk calculators and slow computing devices operate in digits, but in straight decimal numbers. Use of straight decimal numbers makes it difficult to compute at high speeds.

Further, electronic devices for operating in decimal numbers require involved circuitry. Therefore, most computing machines now operate in binary code. Readout, or presentation of the results, is given in either binary, binary-coded decimal, octonary, or decimal presentation. However, since the insides of the machine and its logic are constructed to operate in binary code, this is the system to be used throughout this work. Methods will be described to permit the various readouts in other codes to be obtained. However, the logic and machine operation is usually *straight binary*. Some practice with this code is recommended before attempting to work logical design problems in automation.

Answers to Test on Page 1930

1. d	3. c	5. c	7. a	9. a
2. b	4. c	6. b	8. c	

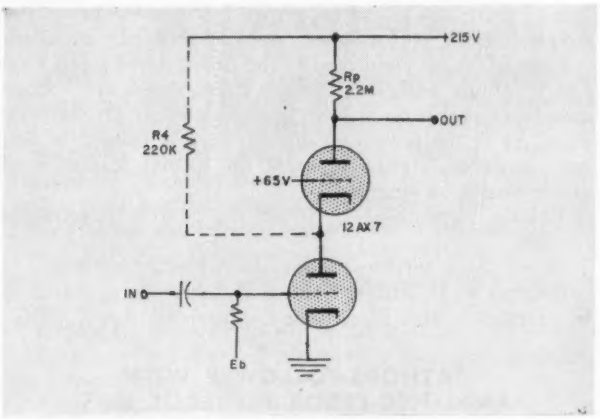
ELECTRONIC CIRCUITRY

MILTON H. ARONSON and **CHARLES F. KEZER**

The circuit is the heart of all electronics. Here are six more basic and interesting circuits. Unless marked, resistors are in ohms, capacitors in microfarads.

CASCODE AMPLIFIER HAS VOLTAGE GAIN OF 1500

The term "cascode" has been applied to the dual-triode amplifier of the type shown (with R_4 disconnected); the plate of the input grounded-cathode stage drives the cathode of the fixed-grid stage directly. The cascode exhibits pentode-like characteristics, including high internal resistance (measured in megohms; conventional triode amplifier internal resistance is of the order of 10-100K ohms).



As in a pentode amplifier, voltage gain increases with increased plate load impedance (R_p). When the plate load is a resistor, however, as in the basic circuit shown (R_4 disconnected), this increased voltage gain can be obtained only by increasing plate supply voltage beyond normal practical values. Reason for this is that the mutual conductance (g_m) of the lower triode, which largely determines the voltage gain, falls off with decreasing plate current. If the plate load resistor is increased, and no corresponding increase in plate supply voltage is made, the resulting decrease in plate current produces a decrease in g_m which offsets the expected improvement in voltage gain.

The simple modification shown allows high voltage-gain to be obtained with normal B-supply voltages. Addition of R_4 in the circuit increases the voltage gain from 100 to 1200, with bias voltage E_b adjusted to maintain a drop of 20 v dc across R_p. An additional plate current of 670 ua is supplied to the lower triode through R_4, producing an increase of over 10 times in its g_m, and improving the circuit voltage gain by nearly the same factor. At first glance it might appear that R_4 is shunting the upper triode and would thus impair performance; however, the impedance at the plate-cathode junction is low and is virtually unaffected by the added resistor. Circuit is superior to the "starved-amplifier" (which also produces high gain at low plate currents) in gain, stability, and frequency response. Application of modified cascode to a voltage stabilizer is shown in the next circuit.

Gain: Depends on operating point; 1200 at 20-v dc drop across R_p, increasing to 1500 at 100-v drop. Gain of 1700 was obtained by increasing R_p to 4 megohms.

Output impedance: 7 megohms in parallel with R_p; approx. 1.5 megohms in circuit shown.

Frequency response: No lower limit; upper limit depends on capacitance load at output. Gain was measured at 500 cps.

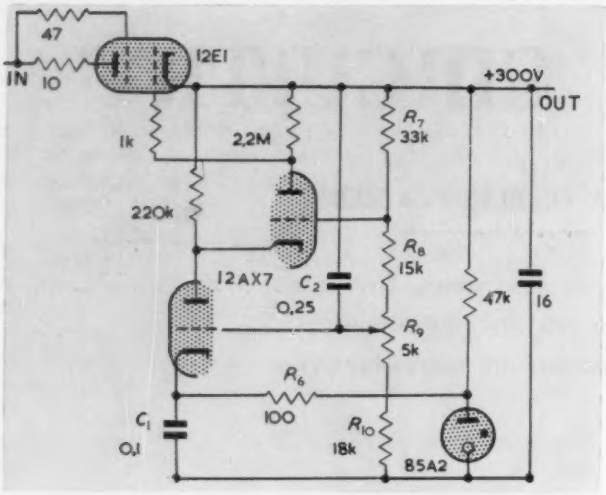
B supply: 215 v dc at 0.7 ma. Bias voltages of +65 v and about −1 v dc also required.

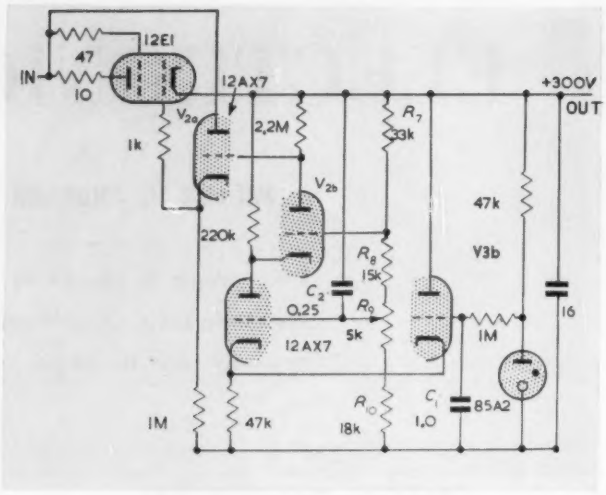
Source: V. H. Attree, College of Technology, Manchester England; also *Electronic Engineering*, April 1955.

VOLTAGE REGULATOR WITH CASCODE AMPLIFIER

The unusually high voltage gain of the modified cascode circuit makes it a natural for an improved degenerative-stabilizer (or voltage-regulator) circuit. Principle of operation is the same as the conventional regulator, with the cascode replacing the pentode amplifier tube (such as 6AU6) often used. Changes in the 300-v d-c output, resulting from line-voltage or load-current changes, appear at the grid of the lower triode via the voltage divider across the output. As the cathode voltage of this triode is held fixed by the gas regulator tube 85A2, grid voltage changes are amplified and applied to the grid of the series regulator tube. Polarity of the amplified voltage is such as to correct the original fluctuation, reducing it by a factor equal to the reciprocal of the circuit gain. Superiority of the cascode, with its voltage gain of over 1000, compared to a pentode gain of perhaps 100, is thus evident. Internal impedance and hum from the input are reduced by the same factor.

Capacitor C_1 decouples the lower cathode of the 12AX7, avoiding reduction in gain at high frequencies due to the impedance of the neon regulator. Resistor R_6 prevents relaxation oscillations between the 85AZ and C_1. Capacitor C_2 improves performance by eliminating attenuation of the voltage divider at high frequencies. Output impedance is maintained low at frequencies above 2.5 kc (where the cascode gain begins to drop off) by the 16-uf capacitor across the output. This drop in gain results from shunting of the high output resistance of the cascode by 32-uuf effective capacitance existing at the grid of the 12E1.





The 12E1 and 85A2 are British types, USA types may be used with minor modifications. Type 12E1 is roughly comparable to an 807; it passes 100 ma at a plate-cathode potential of 135 v with grid-cathode voltage of −20. Transconductance at this operating point is 2800 micromhos. Type 85A2 is comparable to the VR 90; its voltage drop is 85 volts.

Careful layout is needed to achieve low hum and noise; voltage-adjusting potentiometer R_9 should be mounted close to the grid pin of the 12AX7.

Voltage regulation: ±0.4 v for ±10% change in line voltage.

Output impedance: 0.5 ohm at dc, decreasing to 0.2 ohm at frequencies up to 50 kc; this compares with 2 ohms for usual pentode stabilizer.

Input: 525 v dc no-load.

Output: 300 v dc; other output voltage can be obtained by modification.

Hum and noise: May be held to 100-200 uv at output with careful layout; value depends more on stray pickup than hum on input side (which is 2-5 v).

Source: V. H. Attree, College of Technology, Manchester, England; also *Electronic Engineering*, April, 1955.

VOLTAGE REGULATOR WITH BALANCED CASCODE AMPLIFIER

Improved regulation against line-voltage changes and the ability to drive several series regulator tubes (to obtain higher load-current capacity) are achieved in this voltage regulator with balanced stabilizer circuit.

In the preceding circuit, the principal limit on the voltage regulation (for line-voltage changes) is the change in output voltage resulting from heater voltage changes of the 12AX7 tube, which changes alter the contact potential of the lower triode; this has the effect of a spurious grid-cathode signal. In the balanced circuit, V_{3b} (½ of a 12AX7) is added to compensate this effect.

To understand the operation of V_{3b}, suppose that small but equal negative voltages were introduced on both grids of V_3. The voltage at V_{3b} grid, since it is negative, produces a drop in the common cathode potential; this in turn produces a drop in the plate potential of V_{3a}. The equal negative signal on the grid of V_{3a}, however, produces the opposite effect at its plate—that is, an increase in plate potential. Thus if the two halves of the tube are similar, effect of contact-potential changes can be reduced substantially.

The second major change in the circuit is the addition of a cathode-follower between the cascode output plate and the 12E1 grid. This isolates the input capacitance of the 12E1 from the cascode output, resulting in improved frequency response. This improvement is not vital when only a single series-regulator tube is used, as shown. If, however, several series tubes of the same type were connected in parallel with the 12E1 to obtain greater current carrying capacity, the cathode-follower V_{2a} would still be able to drive this larger capacitive load; in the preceding simpler circuit, performance might be seriously impaired.

Plate of V_{2a} is connected to the unregulated input voltage to obtain sufficient voltage drop across it; voltage variations at this point have negligible effect on performance. As in the preceding circuit, care is needed in layout; however, circuit presents no special problems of either layout or stability.

Voltage regulation: ±70 mv for ±10% line-voltage change.

Other characteristics: Equal to preceding circuit.

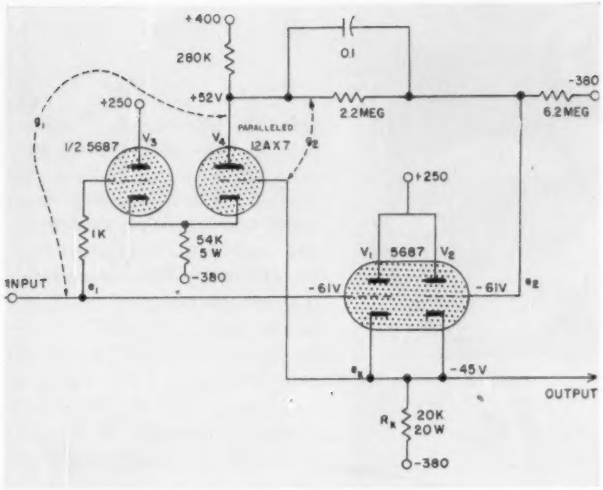
Source: V. H. Attree, College of Technology, Manchester, England; also *Electronic Engineering*, April, 1955.

CATHODE-FOLLOWER WITH AMPLIFIED-ERROR FEEDBACK HAS OUTPUT IMPEDANCE OF LESS THAN 1 OHM.

A direct-coupled driver for an output tube which is driven into the positive grid region must have low output impedance (Z_o) and wide dynamic range (that is, it must be capable of supplying large positive peak current to the grid of the driven tube). The output impedance of a conventional cathode follower is usually of the order of several hundred ohms, whereas an impedance considerably below 100 ohms may be required for low distortion. (Note: Z_o can be measured by loading a circuit until the output signal is reduced to ½ its no-load value; Z_o then equals the applied load if both Z_o and load are resistive. If not, both must have same phase angle.)

A driver which meets the requirements of low Z_o and wide dynamic range is shown. (It is called a PACFD, or "parallel-augmented cathode-follower driver" by its originator.) It amplifies the difference between the output and input signals and adds the amplified error to the output, thus restoring the output to esentially the level of the input and effectively lowering the Z_o.

Tube V_1 is the basic cathode follower. Tube V_4 is the amplifier which receives both the input signal (from V_3) and the output signal (from V_1). Difference, or error, between these two signals is amplified 70 times and added



to the output via V_2. Hence Z_o and distortion are reduced greatly.

In common with other cathode followers, circuit is incapable of delivering a negative current in excess of the quiescent current (16 ma) of V_1 and V_2, which are essentially in parallel. However, it can deliver hundreds of ma of positive current at low distortion. The +250-v and −380-v supplies must be capable of supplying these currents with good regulation.

Output impedance (Z_o): 5.6 ohms over a wide frequency range; less than 1 ohm with 100 ma flowing. (Note: conventional cathode follower using same tube and operating point has Z_o of 370 ohms.)

Output: Up to 100-v rms no-load with practically no distortion. Circuit can drive grid of triode-connected 807 tube 56-v positive with intermodulation distortion of 4%.

Available signal swing: Negative output current is limited by quiescent current of V1 and V2 (approx. 16 ma); peak positive current can exceed 300 ma; more than 200 ma can be supplied without appreciable distortion. Available voltage swing is about 300-v peak-to-peak with no or light load; somewhat less with heavy load.

No-load gain: 0.986

B Supply: No-load supply +250-v at 23 ma; −380-v at 23 ma; +400-v at 1.2 ma. Supply must provide added load requirements also.

Formulas: Gain of conventional cathode follower $\cong \mu/(\mu + 1)$

Output impedance of conventional cathode follower $\cong r_p/(\mu + 1)$

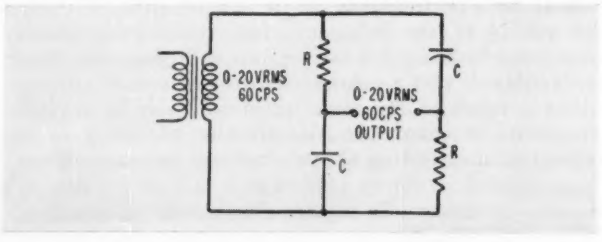
Gain of PACFD $\cong \mu(1 + g_1)/[\mu g_2 + 2\ (1 + \mu)]$

Output impedance of PACFD $= r_p/[\mu g_2 + 2\ (1 + \mu)]$

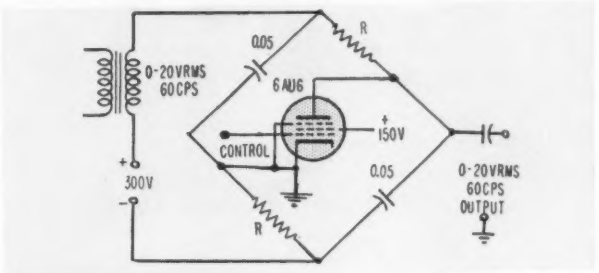
Source: J. R. Macdonald, Texas Instruments, Inc., 6000 Lemmon Ave., Dallas 9, Texas, also *IRE Proceedings*, July, 1955.

PHASE SHIFTER

Signals of variable phase are needed in many circuits. This phase-shift circuit, developed for use in a grid-controlled thyratron power supply, should find other applications, such as thyratron motor control circuits. (In such motor-control circuits the load is placed in series with the thyratron, which has an a-c plate supply; the phase of the triggering signal applied to the thyratron grid then determines the duration of the half cycle during which the thyratron can conduct and, therefore, the average current through the load or motor.)



The basic phase-shift circuit (see first illustration) is a phase-shift R-C bridge, containing two nonlinear resistors (R) and two capacitors (C). The output voltage of this bridge equals the input voltage in amplitude, and lags it in phase by a phase angle $-2\tan^{-1}\omega CR$. In the actual circuit (see illustration 2), the value of the resistors is



controlled by a 6AU6 to effect the phase change. Note that in the complete circuit, the d-c plate-current path is through the two resistors and the 6AU6. The circuit produces about 150 degrees of phase shift in the 60-cycle waveform by a 3-volt d-c control signal applied to the 6AU6.

The resistors are Carborundum Type BNR, whose resistance varies approximately as the −3.5 power of the voltage across them. The d-c control voltage to the 6AU6 varies the current through the resistors, thereby changing their value and producing the phase shift. The resistance varies from about 50,000 ohms to 1 megohm for current variation from 0.02 to 2.5 ma through the tube.

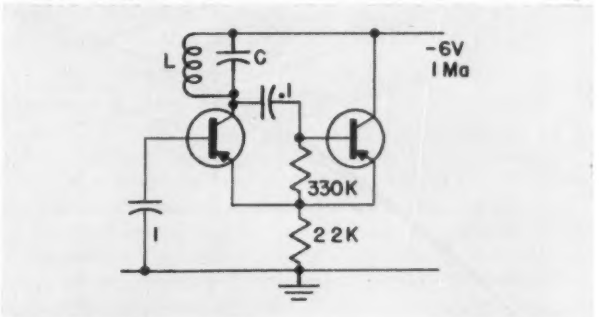
Control signal: 3 v dc produces about 150° phase shift in output.

Output: Same as a-c input from transformer, with phase dependent on control signal; up to 20 volts without noticeable distortion. Output should be to a high-impedance circuit such as a cathode follower to avoid changing phase by loading of bridge.

Source: W. F. Coombs, U. of Rochester, Rochester, N. Y.; also *Electronics*, Dec., 1954.

TRANSISTOR OSCILLATOR

Two junction transistors are used in this oscillator which draws only 6 mw from the power supply. Similarity to the analogous vacuum-tube circuit using cathode-coupling is evident. Frequency is determined by choice of L and C; operation at frequencies to 500 kc has been obtained with CK721 pnp transistors; 1.5 megacycles with TI-201 npn type.



Power supply: 6 v at 1 ma.

Source: Frank C. Alexander, Jr., Gulf Research & Development Co., Pittsburgh 30, Pa.; also *Electronics*, Dec., 1954.

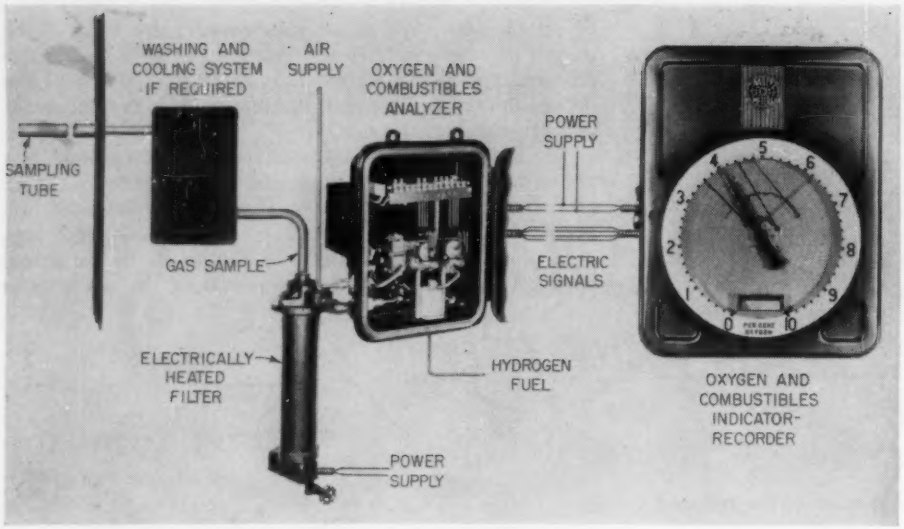


Fig. 1. Typical oxygen and combustibles analyzer system comprises sampling system, analyzer, and recorder.

Gas Analysis in Steel Mills

R. R. SWAIN and **J. A. HAYS**
Bailey Meter Company

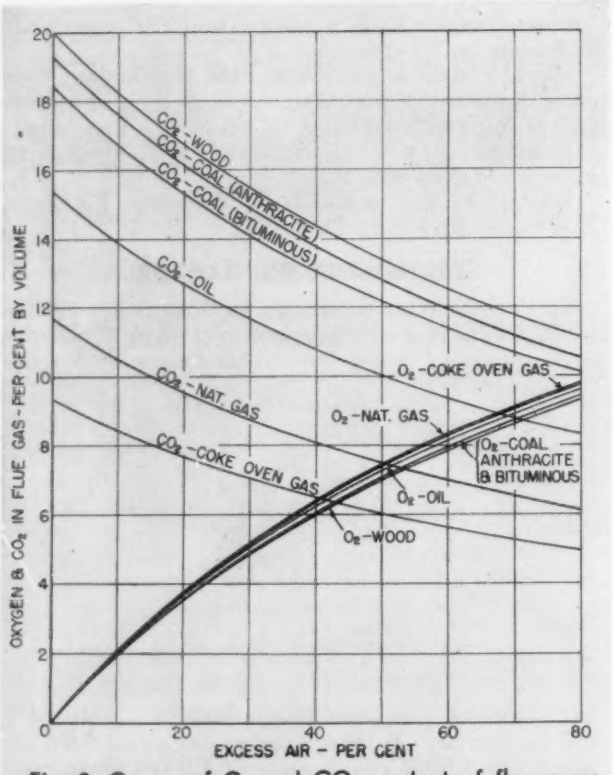

OXYGEN & CO_2 IN FLUE GAS - PER CENT BY VOLUME
EXCESS AIR - PER CENT
CO_2 - WOOD
CO_2 - COAL (ANTHRACITE)
CO_2 - COAL (BITUMINOUS)
CO_2 - OIL
CO_2 - NAT. GAS
CO_2 - COKE OVEN GAS
O_2 - COKE OVEN GAS
O_2 - NAT. GAS
O_2 - COAL ANTHRACITE & BITUMINOUS
O_2 - OIL
O_2 - WOOD

Fig. 2. Curves of O_2 and CO_2 content of flue gases for various fuels show that CO_2 content varies widely with fuel variation, whereas O_2 content remains fairly constant. For this reason, use of O_2, rather than CO_2, is preferred for control of many combustion processes.

CONTROL of excess air in any combustion process is necessary for fuel economy. Various methods to determine excess air have been used. For a given fuel and furnace there is an optimum value of excess air for maximum fuel economy. Operating below this point results in loss of unburned gas, and above this point in stack loss.

In the Steel Industry other factors in addition to fuel economy must be considered. For example, in some processes it is necessary to operate with an excess, and in others with a deficiency, of air in order to provide the finished or semi-finished product with the correct chemical analysis, to prevent scale, or to produce a scale which can be easily removed in the rolling process.

Methods for Air-Supply Control

The methods used for measurement and control of air supply to combustion processes have been quantitative and qualitative. Quantitative measurements (metering of fuel and air flow) have long been used for successful control where the fuel quality remains constant, and where the air supply can be measured properly under all conditions.

Today, most steel-plant furnaces are equipped to burn several fuels individually or in combination. Further, the quality of the individual fuel varies considerably from hour to hour. Air temperature will also vary from day to day so that a volumetric measurement of air flow will not result in the same quantity of air by weight. Therefore, if volumetric measurement of air is to be helpful in maintaining correct fuel/air ratio conditions,

Presented at Conference on Instrumentation for the Iron & Steel Industry, Pittsburgh, 1955.

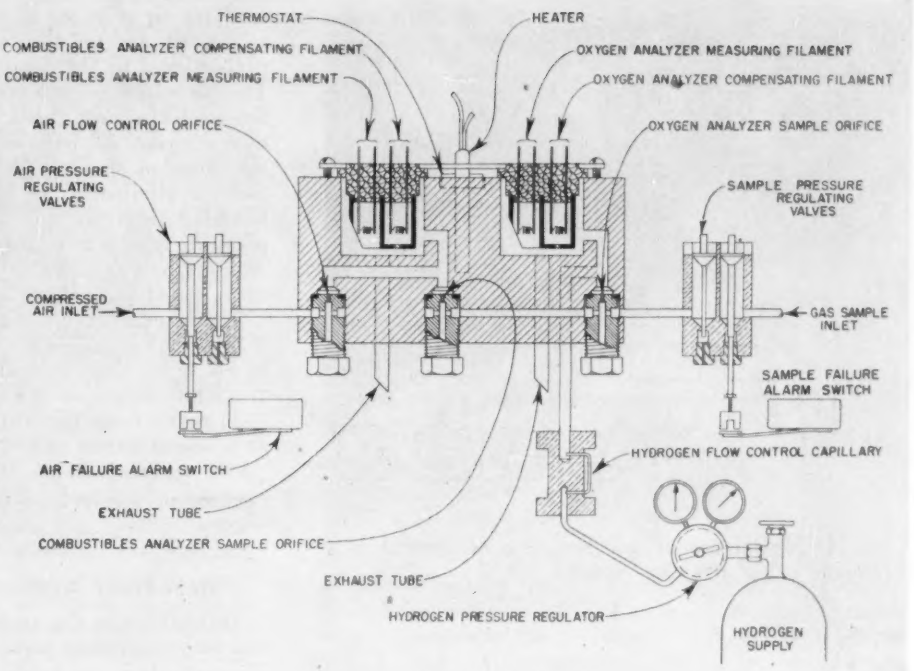


Fig. 3. Schematic of catalytic-combustion type of gas analyzer. Combustibles analyzer is unit on left of main block; oxygen analyzer is on right of main block. Both use noble-metal filaments in a modified Wheatstone bridge circuit. Catalytic action of noble metal filament in presence of gas raises temperature above the ignition point. Resistance of filament depends on temperature of filament which depends, in turn, on the amount of combustibles (in left unit) or oxygen (in right unit).

Gas analysis has become indispensable in minimizing fuel costs. This article shows how the equipment can be adapted to steel-mill applications where factors other than economy must be given consideration—in blast furnaces, open hearths, soaking pits, reheating furnaces, annealing furnaces, boilers and oxygen plants.

temperature compensators must be used. These devices are fairly well developed and available.

Measurement of fuel *quality* is not so easy. Automatic gas *calorimeters*, although suitable for one given gas, may not be suitable for a mixture of gases with wide variations in heating value. Also, they are often expensive, complicated, and slow in response.

Qualitative measurements (gas analysis for content) have been used for many years as a means of determining correct combustion conditions. This method consists in analyzing a sample of the combustion gases. The first instrument was the hand-operated Orsat, by which the operator could analyze for CO_2, O_2 and CO content. Later improved models were made which could analyze for other unburned gases as well. This method was laborious because of the hand sampling, and required considerable time if a complete analysis was to be taken. Therefore, most of the analyses were limited to the determination of CO_2 content. However, furnace conditions can vary too rapidly for this inherently slow method.

Automatic CO_2 Analyzers

The next device to be generally used was the automatic CO_2 analyzer, now of lesser value because in modern steel plants measurement of CO_2 is only of limited value in the determination of combustion conditions. Excess air will vary widely with the same percentage of CO_2 for different fuels, as shown in Fig. 2. Likewise, the excess air will vary for a given percentage of CO_2 if the quality of the fuel is not always the same. In addition, the value of CO_2 will drop when CO or other unburned hydrocarbons are present so that a reading of CO_2 for a given fuel will not furnish data on true excess or deficiency of air. These inherent disadvantages of combustion control via CO_2 led to the development of other analyzers based on measurement of oxygen.

Examination of the formula for excess air of combustion is helpful in determining the direction of later developments. Total air (T_A), which is 100% theoretical air plus the excess air, is expressed by the equation: $T_A = N_2/[N_2 - 3.78\ (O_2 - CO/2)]$. In most combustion applications, it is desired to operate at a point where CO will not be present. Therefore, the factor most representative of excess air is oxygen. As shown in Fig. 2, for a given value of excess air the oxygen content of the flue gas is practically the same for any fuel. This is true for all fuels used in a steel plant except blast-furnace gas. (The deviation here is due to the high percentage of nitrogen in the blast furnace plus the nitrogen which is associated with the air used for combustion.)

Oxygen Recorders

Oxygen recorders have been developed using the thermal-conductivity principle, the catalytic-combustion principle, and the paramagnetic properties of oxygen. The catalytic-combustion principle seems to be particularly practical because it can be used also for the measurement of the combustible constituents. Combination of oxygen and combustibles measurements is especially desirable for combustion processes because these measurements enable the operator to operate at as low an oxygen value as possible without getting into an unburned-gas condition.

Catalytic-Combustion Type of Gas Analyzer

A schematic of the analyzer is shown in Fig. 3. (Fig. 1 shows appearance of this analyzer). Two filament assemblies are mounted in a stainless-steel, temperature-con-

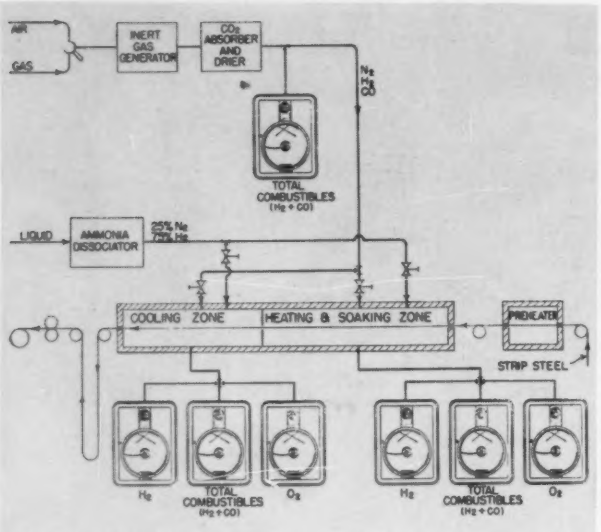


Fig. 4. Typical use of gas analyzing equipment in a continuous strip-annealing process.

trolled block. The gas sample is delivered under pressure from the sampling system after passing through a pressure regulator, which consists of two free-floating pistons in cylindrical chambers, much as in a "dead-weight tester." The gas under the pistons is thereby maintained at accurate pressure. The walls of the cylinders contain vertical slots, through which 99% of the sample is discharged to atmosphere. By throwing away a large volume of sample at this point, the velocities in the sample may be held at a high level, and the over-all response time can be increased.

The sample, under constant pressure, enters the constant-temperature block, and then passes through two restricting orifices in parallel. One orifice supplies a gas sample to the oxygen cell; the other supplies a sample of the gas to the cell for measuring combustibles. On the downstream side of the oxygen-cell orifice, hydrogen is added to the sample from a cylinder (through a pressure regulator and a restricting capillary). On the downstream side of the combustibles orifice, air is added to the sample via a pressure regulator.

The oxygen and combustibles portions of the analyzer are similar, both operating on the catalytic-combustion principle. The cells for both analyzers are identical in construction; each consists of two noble-metal filaments mounted on a common base. Each of these filaments forms a link of a modified Wheatstone bridge. The two filaments are covered by a shield on the base and are separated from each other by a metallic wall. One is the measuring filament; the other a compensating filament. The use of two filaments in one side of the bridge minimizes the effects of small variations in bridge voltage, ambient temperature, and gas thermal conductivity. The measuring filament is located in a chamber whose walls partly consist of a stainless-steel screen. The gas mixture surrounding the assembly diffuses readily through the screen, and the union of the combustible matter with oxygen takes place on the preheated filament. The filament temperature is raised in proportion to the combustible-gas burned.

In the oxygen-analyzer portion of the device a measured volume of hydrogen gas is added to the gas sample previous to its admission to the cell. The hydrogen unites with the oxygen, and the rise in temperature of the measuring filament is proportional to the oxygen content of the sample. Similarly, in the combustibles portion of the analyzer air is added to the sample previous to its entry to the cell, and the rise in temperature of the filament is proportional to the combustibles content of the sample. The gas mixtures leave both analyzing cells through stainless-steel discharge tubes which conduct the gases to the case exterior. All parts in contact with the sample gases are made of stainless steel. Corrosion of electrical contacts is eliminated by preventing the flue gases from touching them. In addition, the blow-off from the air pressure regulator in the analyzer case keeps it purged with air, and excludes any corrosive atmosphere which is often found in analyzer locations.

The standard range for the analyzer is from 0-5% to 0-25%; other ranges are available. The analyzer unit is available for either combustibles or oxygen, or a combination unit (as shown in Fig. 3) for both.

In many cases the instrument is used as a controller, or to sound alarms or shut off valves if the process exceeds preset operating limits. It may be used also to warn the operator of an approaching dangerous or abnormal condition.

Steel-Plant Applications of Gas Analyzers

In addition to the analysis of combustion gases, there are other steel-plant processes which require gas analysis. Prepared gases are used in the blanketing of the product during heating operations. Such gases are (1) the so-called *lean gas*, consisting largely of nitrogen produced by the burning of natural gas or other fuel gas with a slight deficiency of air and subsequent removal of CO_2; (2) *rich gas*, produced by burning a fuel gas with a large deficiency of air; and (3) *dissociated ammonia*, which is 25% nitrogen and 75% hydrogen. All three gases can be analyzed for total combustibles by means of the catalytic-combustion analyzer. For dissociated ammonia gas a thermal-conductivity analyzer also can be used; this is an excellent instrument where only two gases are present. As a general rule, it is not necessary to make separate determination of CO and hydrogen because a definite relationship exists between them for a given fuel. Other steel-plant applications of gas analyzers include the following:

Blast Furnace

Gas analysis for blast-furnace operation is not used widely as yet. Applications will increase as more attention is given to this important phase of steel-plant operations. Analysis of the top gas for H_2, CO, and CO_2 is important because of the effect which these gases have on the production of iron. Determination of the combustibles content, as a measure of the heating value of blast-furnace gas, has been adopted in several plants; the catalytic-combustion type of analyzer is generally used.

Open Hearth

In open-hearth-furnace operation, gas analysis in the past has met sampling difficulties because of the high temperature of gases, the dirt burden and its character. However, most of this has been overcome as will be described. Another deterrent has been a psychological one. In order for any instrument to be of value, however good it may prove to be mechanically, it must be used by the operating staff. Its greater use has yet to be sold to the operator.

For an open-hearth furnace, an oxygen and combustibles analyzer is an effective means in securing correct and efficient operation. Today, most open-hearth shops use combinations of fuels—coke-oven gas, tar, pitch, and oil. All vary in heating value. Combustion-air temperature

does not remain constant from beginning to end of a firing cycle. In addition, air leakage thru furnace and checkers is not uniform or measurable by quantitative means. During a portion of the heat, CO is liberated from the bath; this also is an unmeasurable quantity. Control by gas analysis can correct all of these factors. Where oxygen is used for carbon reduction, it must be done efficiently because its cost is high. An oxygen recorder will furnish data for efficient utilization of the oxygen.

For best results, a fuel-totalizing system with fuel/air ratio control or separate flow control of fuel and air is recommended. The oxygen recorder can be used to adjust the set point of the fuel/air-ratio controller, or the set point of the air-flow controller if separate controllers are used. Where oxygen is used for reduction, an oxygen recorder will make compensation of the air-flow measurement superfluous.

Soaking Pit

Soaking pits have to operate over a fuel turndown range of from five to one to as much as twenty to one, depending on the individual installation. Most fuel/air-ratio controls will not be able to handle this wide range and maintain correct combustion conditions. In addition, use of more than one fuel further complicates control. Where recuperators are used, variations in combustion-air temperature require the use of compensators for air-flow measurements. Much complication of the control and instrumentation can be avoided through use of the oxygen and combustibles recorder. Where fuels are to be mixed or fired singly, gas analysis offers the simplest means of control. The control system can be much the same as recommended for the open-hearth furnace.

Reheating Furnace

Furnaces for slab and billet heating, butt-welding and other similar processes which operate at fairly uniform rates of production offer conditions favorable to the use of gas analyzers. Favorable factors include the use of more than one fuel and the use of air recuperators; unfavorable is the use of multiple zone control, as is the case of slab and rotary hearth furnaces. It is probable that extensive use of continuous gas analyzers for these furnaces will not be made for some time because fuel/air-ratio devices are reasonably suited to these applications. However, for spot-check adjustment of burners etc., portable gas analyzers are useful.

Annealing Furnace

Automatic gas analyzers have been extensively used on continuous strip annealing processes. Fig. 4 shows the use of this equipment. When starting up the process, it is necessary to purge each zone thoroughly with an inert-gas mixture of about 2% CO, 2% H_2, and 96% N_2. Purpose of this purge gas is to reduce the oxygen content of the heating and cooling zones to a safe value before admitting dissociated ammonia or other combustible gas within the explosive mixture range. Use of the oxygen recorder makes manual analysis unnecessary and permits production to be resumed as soon as oxygen is reduced to a safe value, instead of purging for a safe but long length of time. The use of a combustibles recorder on each zone gives a check on the oxygen reading for completeness of purge. When not purging, the combustibles recorder is used to analyze the combustibles content of the zone.

After purging, the furnace is provided with the proper protective atmosphere for steel annealing. Composition of this gas is determined by the plant metallurgist and consists either entirely of dissociated ammonia or a mixture of dissociated ammonia and the inert gas which, of course, reduces the hydrogen content. The thermal-conductivity and combustibles analyzers are used to check the gas analysis of the mixture used in the heating and cooling zones of the machine. An oxygen recorder is used during the annealing period to determine any possible air infiltration.

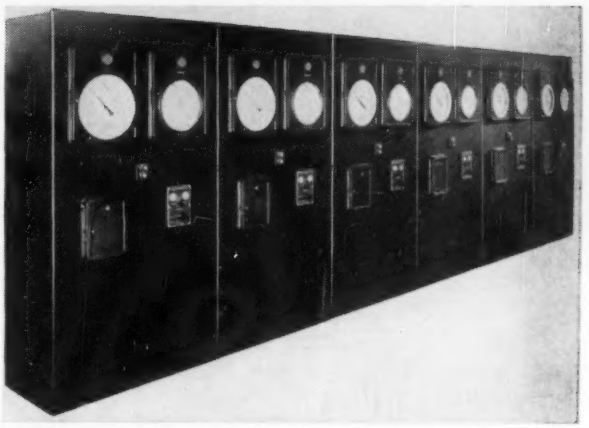


Fig. 5. Panelboard showing control of six inert-gas generators by combustibles recorder-controllers.

For carbon-restoration furnaces and other heat-treating furnaces with protective atmospheres, the combustibles analyzer is used to determine the combustibles content of the furnace itself as a check on the sufficiency of flow of the blanketing gas, as well as on dilution of the gas by infiltration. Oxygen recorders can also be used to detect infiltration of air in furnaces where explosive gases are used for blanketing.

Atmosphere generators are used to provide a purge or blanketing gas. Where the gas is used for purging, the total combustibles content must be maintained below the lower explosive limit or under 4 to 5% combustibles. The combustibles recorder is used widely for controlling atmosphere generators.

A panelboard installation of atmosphere generator control for 7 inert gas machines in the Pittsburgh District is shown in Fig. 5.

Boiler

Many steel mills burn a combination of fuels for their boilers. Use of blast-furnace gas up to the limit of its availability is common; supplementary fuels are oil, coke-oven gas, pulverized coal, coke breeze, and natural gas. The oxygen and combustibles recorder can be used to supplement the fuel/air-ratio device because fuel qualities are subject to change. Even though the oxygen recorder does not furnish a 100% accurate measurement of excess air where blast-furnace gas is used, it is the best device available. Furthermore, the error is not great in the low-excess-air range possible when burning blast-furnace gas.

Oxygen Plant Application

A few steel mills have plants for the manufacture of oxygen used for scarfing, carbon reduction, and oxygen enrichment. Oxygen recorders are used in the operation of these plants to determine the purity of the gas.

Summary

The applications described herein are by no means representative of all of the possible applications in a steel

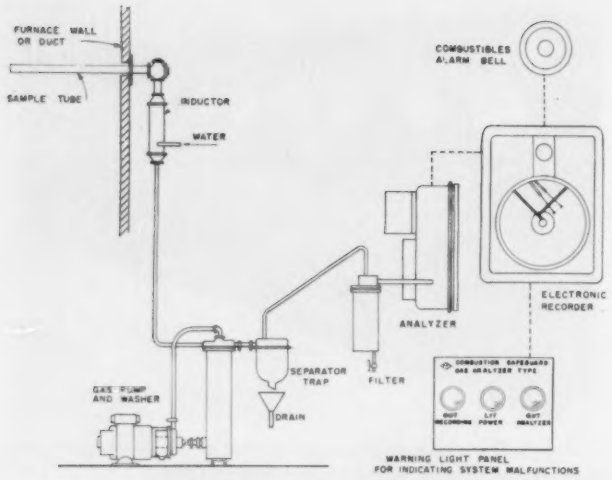


Fig. 6. Gas sampling system with dry-type sampling tube, which can be used where the sample is clean and relatively cool. The water is used to scrub the gas.

mill. However, they are the most common ones. Gas analyzers, when used on clean, non-corrosive gases require little maintenance and give dependable performance. Where dirty corrosive gases must be handled, somewhat more maintenance must be expected. With proper sampling systems, a minimum of maintenance is required. Maintenance and continuity of service are important factors in the selection of any instrument; however, these factors must be considered in terms of over-all value of the gas analyzer in saving fuel or maintaining quality of the finished product.

Sampling Systems

A gas sampling systems for use in the steel industry poses manifold problems. Systems have been developed for use by both the steel industry and other industries throughout the world in determining the percent combustibles or the percent oxygen present in gases emanating from various processes.

The gas sampling system for continuous analysis must be good and reliable. The following requirements must be met: (1) It must draw a sufficiently large sample from the process to give a high speed of response. (2) It must be capable of handling dirty as well as high-temperature gases. (3) It must be reliable with minimum maintenance.

Fig. 6 is a schematic drawing of a gas sampling system that will meet the listed requirements. It consists of a sample tube which is located in the zone from which the gas sample is to be drawn; an inductor which cools the gas sample and also keeps the connecting tubing between the inductor and gas pump washer clear; a gas pump and washer which draws the gas sample from the process and washes it so that it will be suitable for analysis, and a separator trap which separates the water used in the scrubbing system from the gas sample. From the separator trap the gas sample is delivered to the gas analyzer at the required pressure.

There are several types of sample tubes which can be used depending on the requirements of the application. The sample tube shown in Fig. 6 is a dry type, which may be used on applications where the gas sample is clean and at a relatively low temperature. For temperatures below 900°F, a ¾-inch carbon-steel pipe can be used; from 900°F to 1200°F, a stainless-steel pipe; above 1200°F, water cooling is added.

In one water-cooled water-spray-type tube, all surfaces of the tube that come in contact with any gas are made

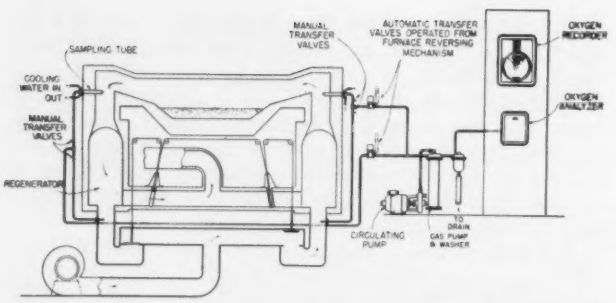


Fig. 7. Typical application of a water-cooled sampling tube in an open-hearth furnace. Water-cooled sampling tubes should be used where temperature exceeds 1200°F.

of Type 316 stainless steel. Through the center of a ¾"-pipe-size inner sampling tube runs a ¼" stainless-steel tube to which a spray nozzle is connected. Water flows down through the ¼" tube under pressure and a spray is formed at the gas inlet of the sampling tube. This spray prevents flyash, dust, or other foreign elements from entering the tube or settling over the opening. Water cooling is provided by a jacket tube; such tubes have been used successfully at temperatures as high as 3000°F on an open-hearth furnace. Fig. 7 shows an application. Automatic transfer valves are installed in the sampling lines, and are connected to the furnace reversing mechanism so that the sample is drawn from the proper end. Other applications of this tube may be in soaking pits, slab-heating furnaces, billet-heating furnaces, etc. If the gases to be sampled are relatively clean the water spray feature of this tube may not be necessary. If the gas sampling zone is below 1200°F it may not be necessary to use water cooling.

The inductor assembly immediately following the gas discharge from the tube cools the gas sample by a water spray and washes the connecting tubing between the inductor and the gas pump.

The gas pump, which pulls the gas sample from the process is usually a motor-driven single-stage centrifugal pump. The suction end is connected to the bottom of a washing chamber, while the discharge supplies an aspirator nozzle in the top of the washing chamber. The nozzle stream creates a suction which draws in the gas sample through a recovery tube. The gas-water mixture undergoes several flow reversals which create a violent scrubbing action and adequately wash the sample. When discharged from the washing chamber the water is separated from the gas sample in a separator-type float trap. The gas sample is delivered to the analyzer under a positive pressure.

If the gases to be sampled are relatively clean, a positive-displacement gas pump such as the "Moyno" type can be used.

For applications such as in an atmosphere generator, where the gas sample is taken immediately after the cracker and where the gases are under sufficient pressure, the gas sampling pump is not required. Usually a sample tube, inductor and separator trap are all that is required; sometimes only a cooling coil and a simple water seal is used. If the sample is taken after the cooler and is under sufficient pressure it can be piped directly to the analyzer. In cases where the gases are sufficiently cool but the pressure is not high enough, a Spencer turbine may be used to boost the gas pressure.

Many other sampling systems have been tried, some with better success than others. Each application has its own requirements.

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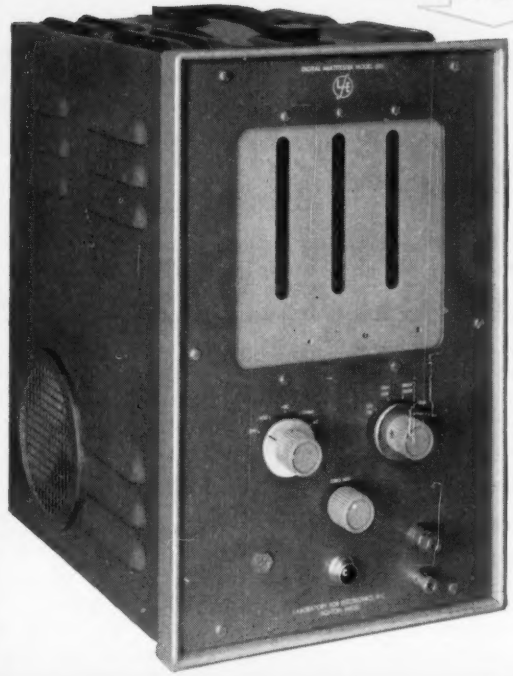

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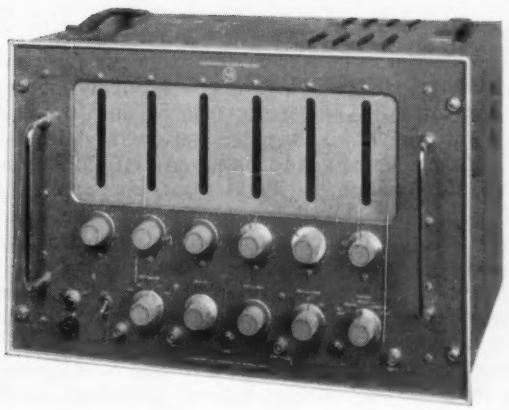

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Plastics for Internal Protection of

Mercury-type Differential Gages

An Epon-Phenolic plastic applied to the internal walls and components of mercury-type differential gages has eliminated corrosion and contamination of mercury for years—and with no maintenance. Plastic coating can reduce maintenance and increase meter accuracy. The application technique is described.

WILFRED G. HAAS

Metal Protection Company,
Bell, Calif.

APPLICATION of protective coatings to the internal walls of differential gages is not new. However, previous to the development of Epoxy resins, various methods and materials had been used with little success.

Some four and a half years ago, gage parts were submitted to us by Pacific Lighting Gas Supply Company in an effort to find a coating material and process of application which would prove satisfactory from the standpoint of economy and long-life protection. An Epon-Phenolic formulation in liquid form was applied and cured to the internal walls and component parts, and the gages were installed in areas where corrosive agents were most prevalent and active. Periodic checks to the present time have shown no effect on the coating, no contamination of mercury from contact with the coating, and no maintenance costs.

Since the original coated instruments were installed, gages protected in the same manner have been put into service in ever-increasing numbers. The process used in coating the first parts remains unchanged, and seems to be the answer to the problem of corrosion in differential meters, gages, and related parts.

December Meeting: *Thursday, the 15th, Rio Hondo Country Club, Downey, Calif.*

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It is the purpose of this article to emphasize the importance of proper selection of plastic used for surface coating, and to outline the steps of correct application which must be followed in order to obtain the protection required, particularly for flowmeters.

Selection of Plastic

Selection of the proper plastic material to be used for a given problem is possible only when all factors are known, yet frequently more than one plastic may be recommended because of the excellent record of plastics in general in combatting corrosion. If there is a choice of equally qualified materials indicated, final decision usually is reached by the corrosion engineer after consultation with the applicator, who may determine the most practical one after weighing the problems pertaining to application on a specific object.

In the case of differential gages it was known that chemical agents, among them hydrogen sulfide, attacked the unprotected walls of the chambers, causing them to become pitted, scored, and otherwise affected in such ways as to impede the action of the mercury. Rust formed within the chambers, contaminating the mercury and causing the over-all effect of corrosion to result in false readings and necessity for frequent cleaning.

It was obvious, then, that the first requirement of a material used in this application was resistance to attack by the chemical agents present. Also necessary was a smooth film surface which would facilitate the rise and fall of mercury with no danger of contamination from

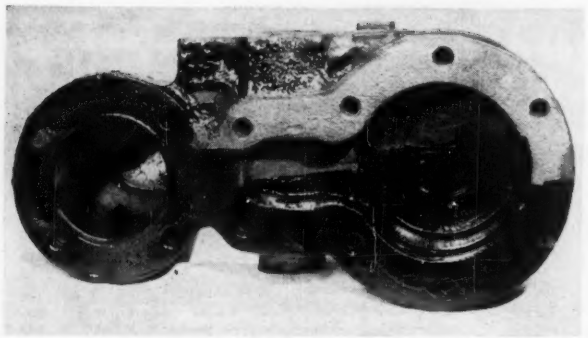

Fig. 1. Smoothness of coated surface on one side of float chamber contrasts with rough, uneven surface of untreated portion of wall.

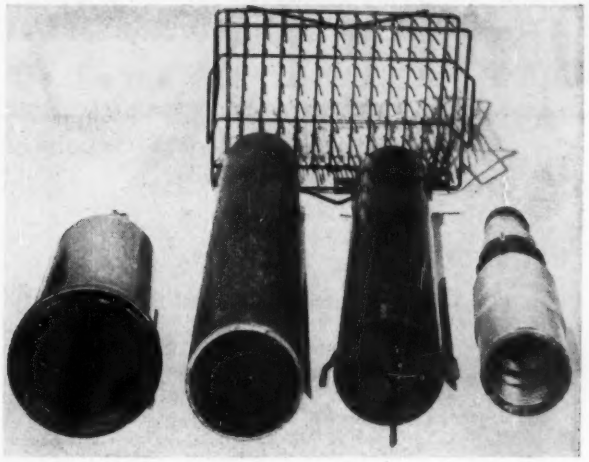

Fig. 2. Internal surfaces of units from portable water-softening equipment and aircraft oxygen cylinders are protected with Epon plastic.

contact between the mercury and plastic. A comparatively thin film was a requisite so as to retain the original dimension as nearly as possible.

An Epoxy-Phenolic formulation was indicated as the proper selection for this application because it seemed to possess all the properties required plus a remarkable quality of adhesion to metal. After a discussion of application problems, it was decided to use this material, and subsequently a procedure was worked out and the parts coated.

The writer here wishes to express his appreciation to Mr. T. K. M. Smith, of Pacific Lighting Gas Supply Company for his co-operation in accepting recommendations at this early stage and in submitting parts for evaluation of this coating. At the time of this first application, Epon resins as surface coatings had been used to a limited extent, and application techniques were not fully developed. It has been through exhaustive testing and service data compiled by Mr. Smith that the fine performance of Epon in this service has been recognized.

Application Technique

The first step in correct application is preparation of the surface to receive the coating. Sandblasting is preferred above all other methods for complete removal of scale, rust, products of corrosion in used parts, and all other foreign matter. Chemical cleaning, wire brushing, scouring with abrasive cloth and other surface preparations are, at best, substitutes for sandblasting when the preferred method is not possible or feasible. The finely etched, virgin metal surface presented by sandblasting provides a perfect base upon which to apply a plastic coating.

The viscosity of the resin to be applied to parts is of great importance in order to avoid heavy spots, sags, or dry film deposit, any of which may cause weakness in the cured film and subsequent failure. Control of viscosity is accomplished by the use of hydrometers, and solvents used for thinning are carefully selected for their action both in the wet stage of the resin and in the curing.

A thin uniform coat of material is applied by spray on the surfaces accessible, or by fill and drain method on parts which are not of a size or shape to allow spray coating on interior walls.

This first thin coating is allowed to air dry for a short period of time, then the parts are placed in an oven where a medium temperature (300°F) drives off solvents and sets the coating. After a short bake and cooling period, a second coat is applied in the same manner as the first, and the pre-bake is repeated. Following a third and, in this case, finish coat the parts are baked at a higher temperature for a greater length of time (425° F for 45 min). The metal itself must reach the desired temperature, and this is checked by means of Tempilsticks.

This final bake results in a complete fusing of all coats to form a hard, homogenous, highly resistant film. Fig. 1 illustrates the smoothness of the coated surface on one side of the float chamber in comparison to the rough, uneven surface of the untreated portion of the wall.

The three-coat system described above produces a film of 0.003″ to 0.004″ thickness, providing protection against all corrosive conditions encountered in a differential gage. Heavier films may be obtained, when required, by postponing the final cure until sufficient coats to reach the desired thickness have been applied, bearing in mind that there is an optimum in this type of coating beyond which loss of flexibility and lowered impact resistance may be present.

Other Applications

This article has dealt with the protection of mercury-type differential gages only, which is but one of many hundreds of uses of plastic coatings for corrosion control. Various Epoxy-resin formulations are in general use both as new applications and as superior replacements for other types of coatings. Fig. 2 shows the use of Epon in protecting the internal surfaces of portable water-softening equipment and oxygen cylinders for aircraft.

Plastic coatings of Epoxy type are almost standard in domestic water softeners, being designated by many different trade names. Refineries and oil fields have recognized the value of plastic-lined pipe, locater tubes, valves, tanks and similar equipment. The food and beverage industries have many installations of plastic-lined storage and processing units. The list is practically endless because of the ability of plastics to protect where other materials may fail.

The use of plastic coatings, properly applied, may be the solution to many costly and vexing problems which confront industry, and the instrument field may justly claim to have "pioneered," in a sense, in its contribution to the establishment of the value of Epon-resin surface coatings.

Briefs . . .

INSTRUMENTS and AUTOMATION

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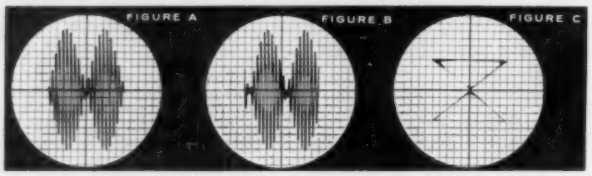
Servoscope

The Servoscope is a multiple signal generator with means for comparing the signal output with the response of a servo system, component, or low-frequency network. The Servoscope output signal is applied to the system under test and to the vertical axis of an oscilloscope. A saw-tooth sweep, generated and synchronized with the output signal, is applied to the oscilloscope horizontal axis and serves as a time base. When the signal is viewed



with this sweep the modulated pattern is as shown in Figure A.

The system response is applied to the vertical axis in place of the signal; any difference in phase will appear as a shift along the sweep time base as shown in Figure B. In order to measure the phase difference between signal and response, the phase dial on the Servoscope is turned so that the response pattern is again similar to that shown in Figure A. Thus, the phase dial has actually shifted the Servoscope output signal an amount equal and opposite to the phase shift in the system under test. The phase lead or lag is then obtained by reading the dial.

In order to improve the reading accuracy of a sine-wave signal output, a synchronized modulated high-frequency carrier can be applied to the horizontal axis in place of a saw-tooth linear sweep. The resulting sharp pattern at zero phase shift provides excellent reading accuracy. This pattern is shown in Figure C.

Frequency range (cps): Model A—0.1 to 20; B—0.15 to 30; C—0.3 to 60; D—0.001 to 20. (*From new 4-page Brochure, TDS-1100, Servo Corporation of America, New Hyde Park, N. Y.*)

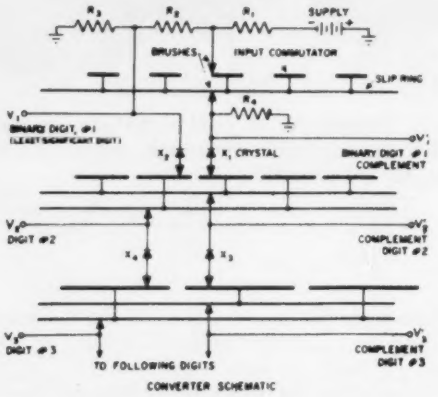
For this literature circle **501** on card.

Digital Converter

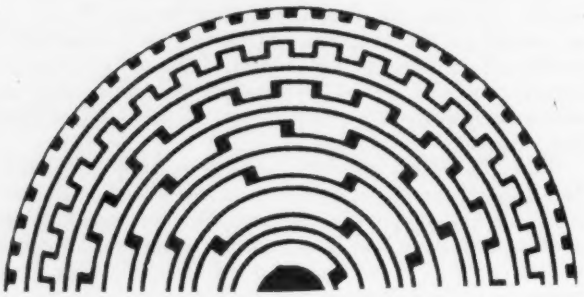
The ADC-1 Digital Converter is a means for transposing analog mechanical information into digital electrical representation . . . The output, which may be read while the shaft is in motion, represents a 13 digit binary number presented in parallel form and in natural binary (uncoded) notation. The output is 2^{13}, or 8,192 counts; 64 input revolutions are required per total count . . . Accuracy is better than 1 part in 8,192, or 0.012%.

Four brushes per digit are used to obtain the unambiguous binary output. The position shown represents the zero position of the shaft . . . all outputs V1, V2, etc., are zero; the complement outputs V1′, V2′, etc., have ones. (The ones are arbitrary values of voltage).

Now move all the brushes to the right so that the input brush is not making contact with the input commutator. Since R4 is no longer connected to the junction of R1 and R2, the voltage at V1′ changes to zero; the voltage at junction of R2 and R3 increases negatively to produce a "1" at output V1. Crystal CR2 now passes voltage to the commutator and slip-ring previously energized by CR1. Output V2′ is, therefore, still energized as before. Since no energized crystals are touching the commutator-slip-



CONVERTER SCHEMATIC



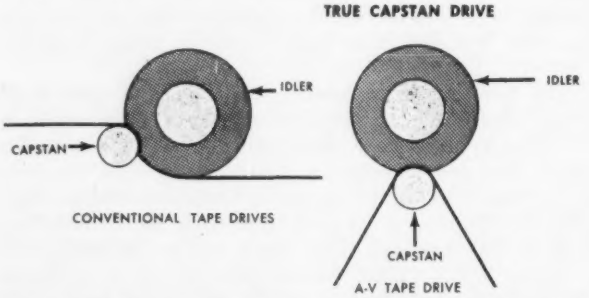
ring-assembly connected to output V2, V2 is at zero voltage, and represents 0.

Thus the output changed from 000 to 001 by moving the brush assembly one segment width to the right. Moving the assembly another segment width will produce the binary 010 . . . The procedure may be continued until the 13 digit binary number has all ones at outputs V1 through V13. (*From new 4-page Bulletin 360, Norden-Ketay Corp., Wiley St., Milford, Conn.*)

For this literature circle **502** on card.

Magnetic Tape Recording

The "building block" feature in A-V tape recording equipment gives the instrumentation profession a flexi-



bility heretofore unavailable . . . a system can be started with a few channels and their number increased as needs become known.

The tape transport is a basic step forward in low-flutter drives. High-frequency flutter is a function of the unsupported tape length across the heads, and it is desirable to reduce this length to a minimum. In the A-V drive the distance between the reel isolating inertia idlers and the

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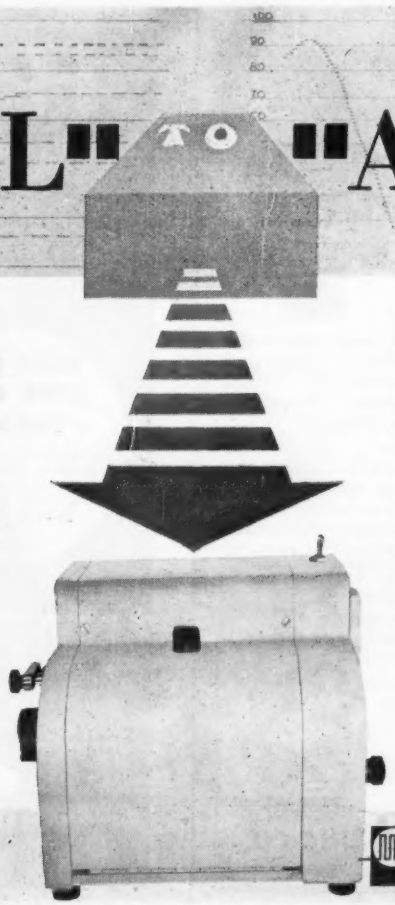

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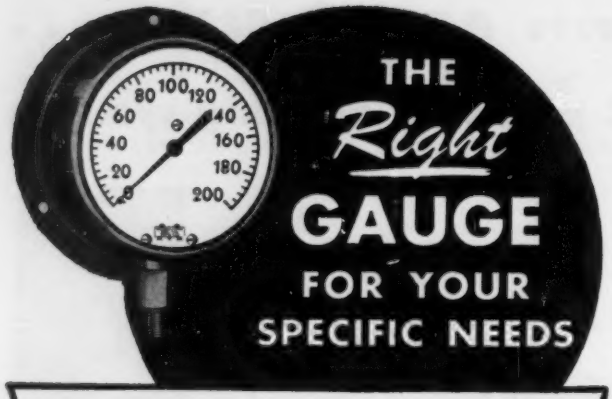

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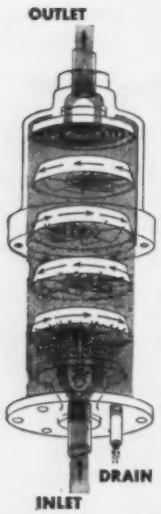

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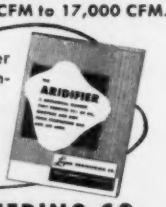

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BRIEFS—CONTINUED

capstan has been reduced to a minimum—a length just sufficient to permit the installation of two A-V Magnetic Head Stacks on each side of the capstan.

In a drive in which the tape arrives on the capstan and leaves on the rubber idler, high-frequency flutter is generated by the idler due to its dimension changing as it leaves the capstan. This sets up stresses in the tape and longitudinal vibrations result. The A-V "W" Type drive provides true capstan drive in which the tape arrives and leaves on the capstan, thus eliminating this source of high-frequency flutter.

Effect of the reel drives on tape motion is reduced to minimum by a large wrap angle on the two reel-isolating inertia idlers.

Frequency response at 7.5 ips tape speed is 300 to 10,000 cps (3 db); 300 to 80,000 cps at 60 ips. (*From new 16-page brochure Bulletin* 103, *A-V Mfg. Corp.*, 730 *Fifth Ave., New York* 19, *N. Y.*)

For this literature circle **503** on card.

Vibration Measurement Techniques

Displacement measurements are used only in instances where the actual amplitude of motion of the parts is important. This would include those cases where the dynamic loading due to the operating machinery in a factory may cause unsafe deflections in flooring and walls or where large amplitude of motion might actually cause parts to strike together, thus causing damage or serious rattle. The deflections observed at the center of a wall panel or a beam, for example, can give useful information about the

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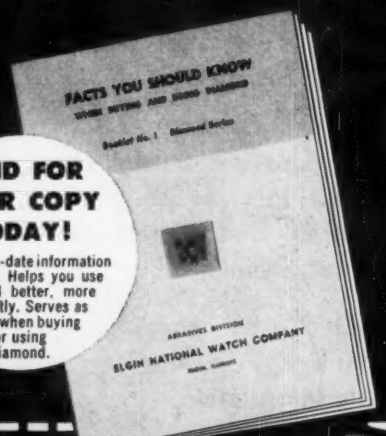

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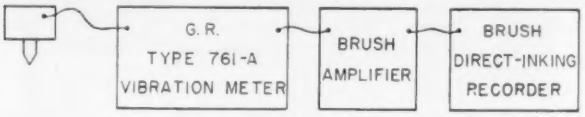
stresses acting in these members. The displacement is not directly a measure of surface strain of the member but is rather an integrated indication of the strain. The strain measured by the usual strain gage is a minute elongation or compression of material between points an inch or so apart; in contrast, the displacement measurement referred to above is the bending of material over a distance of several feet.

Velocity measurements are generally used in noise problems where the radiating surfaces are comparatively large with respect to the wavelength of the sound.

Acceleration measurements are the most practical where actual mechanical failure of the parts involved is of im-



Voltage Ratio	Power Ratio	−db+	Voltage Ratio	Power Ratio
1.0000	1.0000	0	1.000	1.000
.9886	.9772	.1	1.012	1.023
.9772	.9550	.2	1.023	1.047
.9661	.9333	.3	1.035	1.072
.9550	.9120	.4	1.047	1.096

portance, and in many noise problems, particularly those involving small machinery. A general-purpose vibration meter, therefore, must be able to measure all three vibration characteristics.

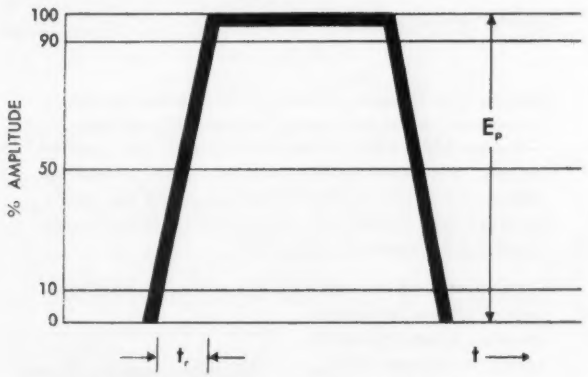
The above equations represent only sinusoidal vibrations, but, as in the case of the other complex waves, complex periodic vibrations can also be represented as a Fourier series of sinusoidal vibrations. These simple equations may, therefore, be expanded to include as many terms as desirable in order to express any particular type of vibration. It will be noted that, since velocity is proportional to frequency, and acceleration is proportional to the square of the frequency, the higher frequency components in a vibration are progressively more important in velocity and acceleration measurements than in displacement readings. (*From new 64-page booklet "Measurement of Vibration," General Radio Co., Cambridge, 39, Mass.*

For this literature circle **504** on card.

Delay Lines

Definitions and Measurements:

1. Attenuation: The loss in amplitude of a pulse measured between input and output pulses, expressed in percent of input pulse amplitude.



2. Bandwidth: Cutoff frequency of network (−3 db point) related to rise time by B.W. (Mc) = 0.36/rise time (usec).

3. Delay time: For pulse delay networks generally considered to be the elapsed time between the 50% amplitude points of the input and output pulses.

4. Characteristic Impedance (Z_o): Equal to the value

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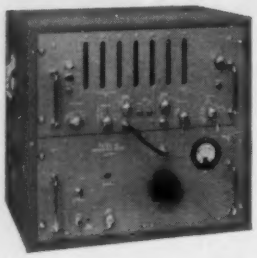

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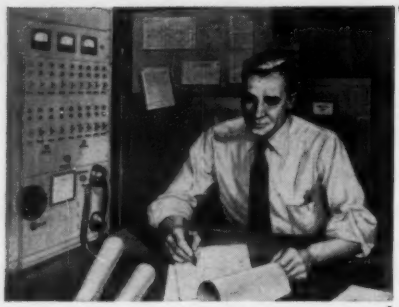

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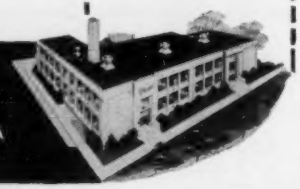

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BRIEFS—CONTINUED

of the terminating resistance which provides minimum reflection.

5. Rise time (t_r): Elapsed time between the 10% pulse amplitude and 90% pulse amplitude point. (See bandwidth.) The rise of a network is defined as the rise time of the output pulse assuming zero rise time for the input pulse. For input pulses with finite rise time, the network rise time is expressed by $t_r = (t_o^2 - t_i^2)^{1/2}$ where t_r = network rise time; t_i = input pulse rise time; t_o = output rise time. (*From new 16-page booklet "Delay Lines," ESC Corp., 534 Berger Blvd., Palisades Park, N. J.*)

For this literature circle 505 on card.

The Land Surface Pyrometer

The Land surface pyrometer provides for the first time a simple and accurate method of measuring the temperature of non-conducting surfaces, such as oxidized metals and refractories.

It is a radiation pyrometer but needs no emissivity correction. It can be used with equal accuracy on any surface other than bright or very lightly oxidized metals. It is necessary to place the pyrometer head on the hot surface and in less than five seconds the true temperature can be read on a portable meter. No battery or main supply is needed, there are no electronic complexities, or corrections, no calculations and no skill is required other than the ability of the operator to read a simple indicator.

The secret of the remarkable performance of this pyrometer lies in a simple fundamental idea. If a concave reflector is placed in contact with a hot surface, the surface and its image in the reflector together form the equivalent of a uniform temperature enclosure. Radiation es-

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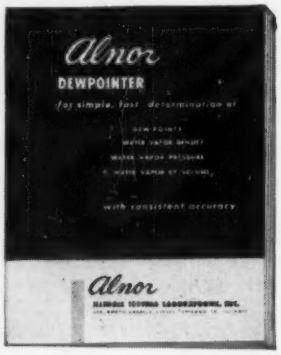

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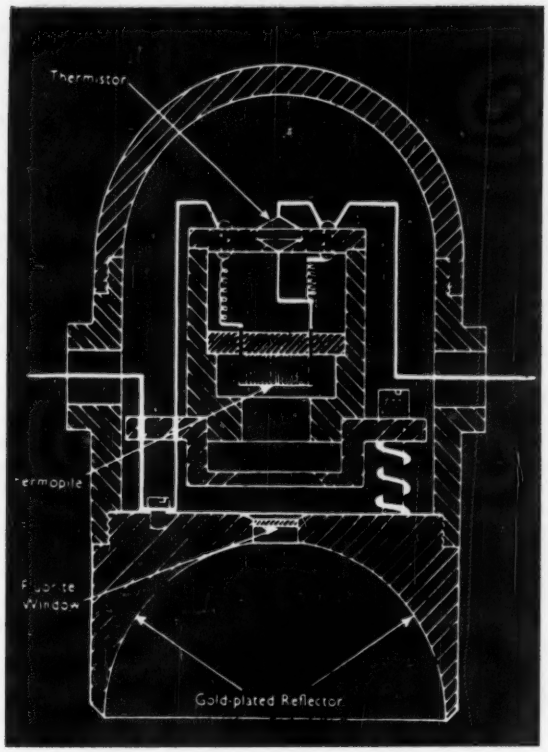


caping through a small hole in the top of the reflector approximates very closely to black-body radiation at the temperature of the surface. The gold plated reflector of the pyrometer is two inches in diameter and has a small fluorite window through which radiation passes to a sensitive thermopile.

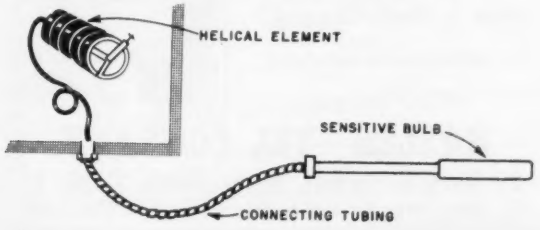
Gold has been chosen for the reflector as it is the best reflector of infrared radiation, and fluorite because it is transparent to all radiation except that of very long wavelengths. This combination of materials enables the pyrometer to be used over the complete range of temperature from 100 to 1300 deg. C.

It is a delightful feature of the pyrometer that it is possible in two minutes to measure the emissivity of any surface using the pyrometer itself for the measurement. A reading is first taken in the normal manner; a blackened hemisphere is then slipped inside the gold plated reflector and a second reading is obtained. The emissivity can then be read from tables as a function of the two temperatures. Such a measurement is only necessary occasionally to check that the emissivity of an unknown surface is not abnormally low. (*From new 12-page booklet "Technical Information," Fielden Instrument Div., Robertshaw-Fulton, 2920 N. 4th St., Phila. 33, Pa.*)

For this literature circle **506** on card.

Filled Thermal Systems

Filled thermal systems consist of a sensitive bulb, connecting capillary tubing, and a bourdon helical element. The sensitive bulb contains liquid, vapor, or gas and is immersed in fluid at the point of desired temperature measurement. As the temperature changes at the sensitive bulb, the pressure or volume within the system will



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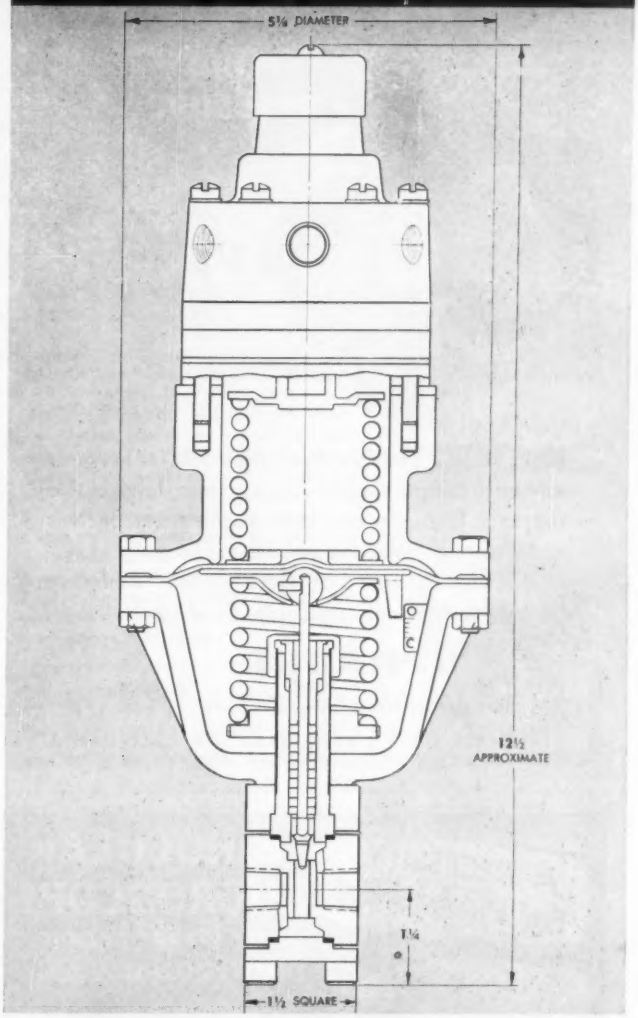

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change, causing the helical element to rotate. This angular rotation is then employed to position pen or pointer of the instrument.

F&P filled thermal systems are classified according to fill (liquid, vapor, or gas) and type of compensation used to eliminate ambient temperature errors:

Liquid Expansion (Class 1A and Class 1B): These liquid systems have the advantage of being applicable to narrow or wide range temperature measurement. Temperature range limits are from −300 to +500°F. They have uniform temperature scales. Sensitive bulbs are smaller than in any other class system, making it ideal when immersion and insertion dimensions are limited. Response is faster than Class IIIB systems and slightly slower than Class II systems. Overrange is available and built into all Class IA and Class IB systems.

Vapor Pressure (Class II): Two types of Class II vapor systems are offered: uniform scale and non-uniform scale. The non-uniform scale system is ideally suited for applications where normal operating temperatures do not vary over 20% of the specified instrument range. These vapor systems are capable of accurate temperature measurement in ranges between −50°F and +450°F. Response is excellent, and sensitive bulb is smaller than Class IIIB systems.

Gas Pressure (Class IIIB): The gas system is capable of temperature measurement beyond the limits of the other systems. The temperature limits are from −400°F to +1000°F. (*From new 24-page Catalog 12-A-10, Fischer & Porter Co., Hatboro, Penna.*)

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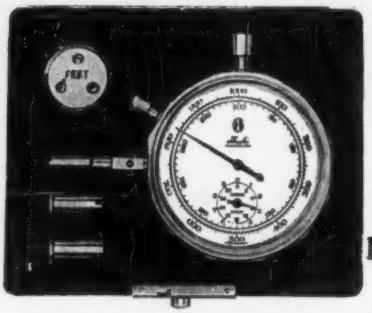

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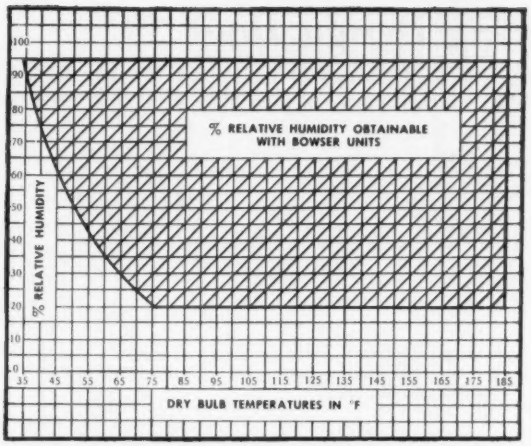

°C	Temp. To Be Converted	°F	°C	Temp. To Be Converted	°F	°C
−168	−270	−454	−17.2	1	33.8	3.9
−162	−260	−436	−16.7	2	35.6	4.4
−157	−250	−418	−16.1	3	37.4	5.0
−151	−240	−400	−15.6	4	39.2	5.6
−146	−230	−382	−15.0	5	41.0	6.1
−140	−220	−364	−14.4	6	42.8	6.7
−134	−210	−346	−13.9	7	44.6	7.2
−129	−200	−328	−13.3	8	46.4	7.8
−123	−190	−310	−12.8	9	48.2	8.3
−118	−180	−292	−12.2	10	50.0	8.9

+200°F, relative humidity between 20 and 95%, altitude to 10,000 ft. Instrumentation provides for recording, control and programming of any combination of variables. (*From new 12-page Bulletin 754, Bowser Technical Refrigeration, Terryville, Conn. which includes tables of relative humidity, standard atmosphere data, temperature conversion tables, etc.*)

For this literature circle **508** on inquiry card.

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DATA SHEET

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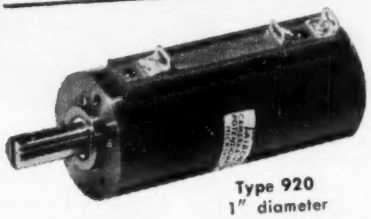

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1" diameter

Ten-turn Potentiometer (24½" coil length)

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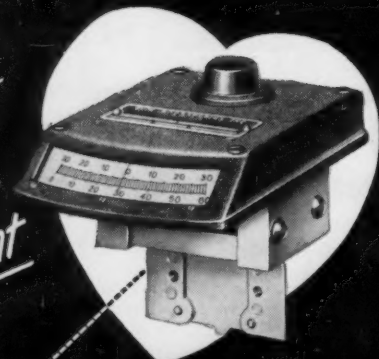

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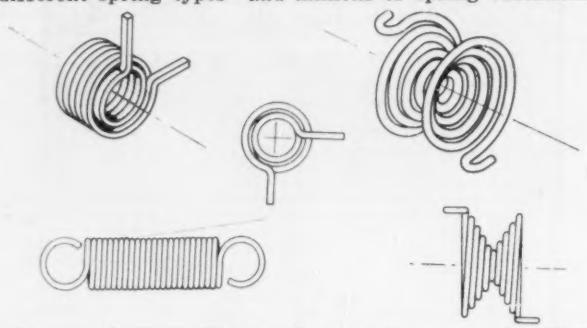

—have evolved. In Hunter Data, springs are classified into five types—compression, extension, torsion, spiral, and Neg'ator. (*From new 4-page set of "Spring Design Data" Sheets, Hunter Spring Co., Lansdale, Pa.*)

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Telemetering, Supervisory Control

Great progress has been made in recent years in the art of Telemetering and Supervisory Control. Power companies petroleum industries, gas companies, and many industrial organizations have come to realize the advantages of remote instrumentation and control of various functions such as temperature, pressure, rate of flow, voltage, current, power, etc. . . . The increasing demand for Telemetering and Supervisory Control circuits establishes the need for equipment which will multiplex and transmit a larger number of individual pieces of information over a single telephone line, microwave, or carrier channel. Certain basic requirements must be met by

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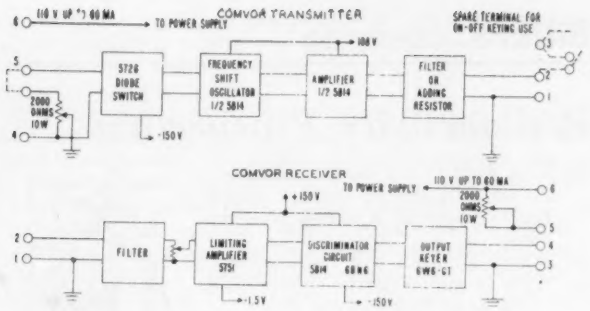

equipment of this type:

1. Equipment must be capable of handling the signals derived from both Frequency and Impulse Duration type Telemetering Systems.
2. Must be capable of acting as a remote switch, either directly or in conjunction with dials, stepping switches, or relay pyramids for Supervisory Control functions.
3. Must provide for the maximum number of telemetering or control channels without sacrificing accuracy and reliability.
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5. Must be insensitive to noise and amplitude variations.
6. Should be capable of handling both high and low speed telegraph signals since in many cases telegraph is used in conjunction with voice for maintenance and control activities.

After studying the industrial requirements the Model 912 COMVOR Audio Frequency Shift Terminal was designed. (*From new 8-page "Product Application Data," Radio Frequency Laboratories, Inc., Boonton, N. J.*).

For this literature circle **510** on card.

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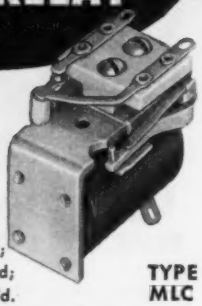

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TYPE MLC

Coil Resistance: Up to 6500 ohms (No. 44 AWG wire).

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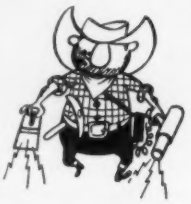
Radioactivity Prospecting



Q: How deep in the earth will a geiger or scintillation counter detect the presence of a radioactive ore body?
Q: Which minerals are radioactive?
Q: Why is radioactivity prospecting based mostly on gamma rays?
Q: How can I earn the government bonus?

(From new 28-page booklet "64 Questions and Answers on Geiger Counters and Scintillometers," Precision Radiation Instruments, Inc., 4223 W. Jefferson Blvd., Los Angeles 16, Calif.)

For this literature circle **511** on card.

Relays

Shown are the five basic forms of contacts in standard relay usage . . . additional combinations of the standard forms are available . . . The single-wound coil is available in resistances from 5 to 12,000 ohms. It is used for fast action.

Double windings are of several types. Coils with two coaxial windings having balanced operating characteristics may be operated from two separate control sources. Currents of equal value hold a relay with such a coil in

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For more information circle **135** on inquiry card.

the non-operate position, any change in either controlling current causing it to operate. This type is used as a circuit balancing device . . . also for a remote or safety release.

It is also possible to provide windings in which a resistance coil is laid over the operating winding, and so wired that it automatically is cut into series with the coil when the relay operates. The resistance cuts down the operating current so long as the relay is held operated.

Tandem-wound coils . . . may be parallel wound so that the relay will operate only when both coils are energized. (*From new 32-page Catalog R-522-4, "North Relays and Automation Components for Industrial Controls, North Electric Co., Galion, Ohio.*)

For this literature circle **512** on card.

Synchro Transmitters, Servos

Synchro Transmitters are for use in position indicating (torque) systems and data transmission (control) systems. (Norden-Ketay provides) 60 and 400 cycle models, and sizes from 10 to 37. Electrical accuracy is 7 minutes in standard units. (*From new 18-page "Manual of Rotating Servomechanism Components, and Adjustment and Setting Tools," Bulletin 362, Precision Components Div., Norden-Ketay Corp., 555 Broadway, N. Y. 12, N. Y.*)

For this literature circle **513** on card.

R-F Bridge

The widespread acceptance (of Type 916-A R-F Bridge for measurements on lines, components and networks in frequency range 400 kc to 60 Mc) has been due to accuracy and simplicity. The new Type 1606-A R-F Bridge incorporates several new features.

As in the older bridge, the resistive and reactive com-

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This personnel monitoring instrument measures the cumulative exposure to gamma or x-rays over a given period of time. The instrument consists of an ionization chamber, a quartz fibre electrometer and a graduated scale and viewing system.

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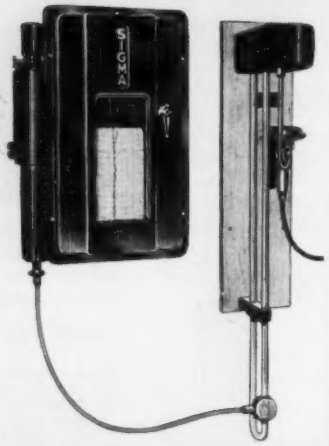

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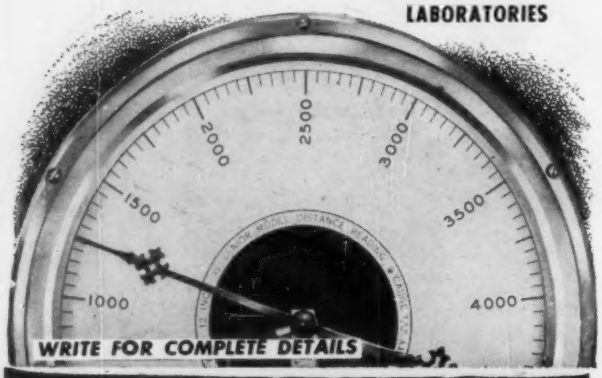

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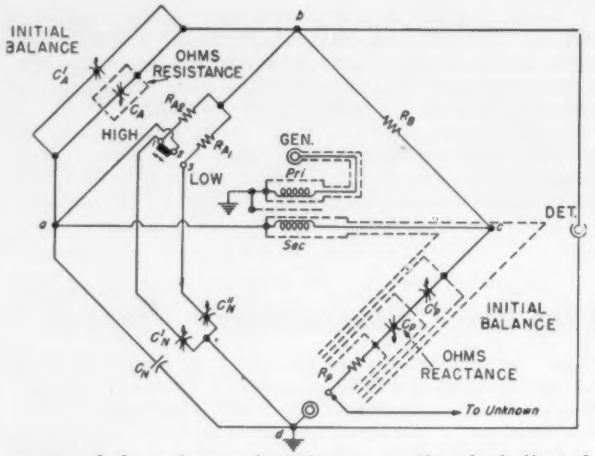

ponents of the unknown impedance are directly indicated on separate dials when the bridge is balanced to a null . . . A modified Schering bridge circuit is used, in which both the resistive and reactive components of the unknown impedance are measured in terms of capacitance, and all balance adjustments are made by a variable air capacitor. (*From new* 12*-page Vol.* 30, *No.* 1 *issue of GR Experimenter, General Radio Co., Cambridge, Mass.*)

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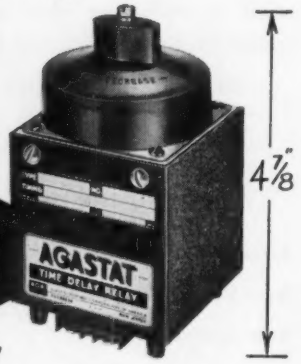
Research Model pH Meter

The Cambridge Research Model pH Meter provides a laboratory instrument for pH and millivolt values. Features: potentiometer with electron-ray null indicator,

Time delays in automation circuits



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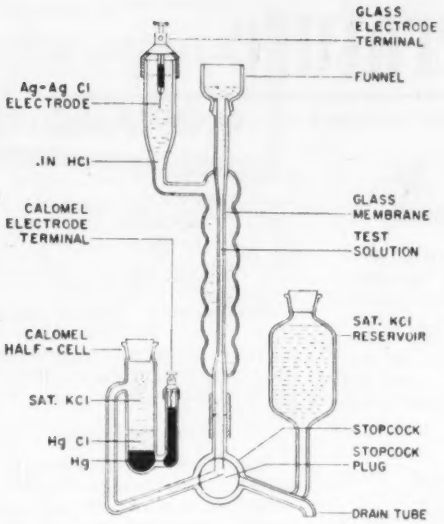

range of 0 to 14 pH and 0 to 1200 millivolts; sensitivity of 0.005 pH; accuracy (reproducibility) of 0.01 pH; over-all accuracy of 0.01 pH between 1 and 9 pH; unique glass electrode system; Weston standard cell which provides constant current in the potentiometer circuit.

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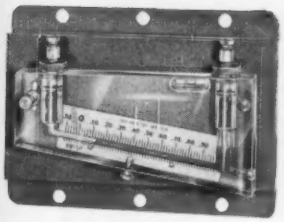

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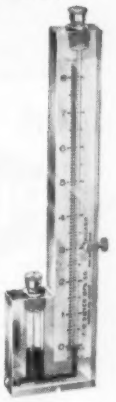

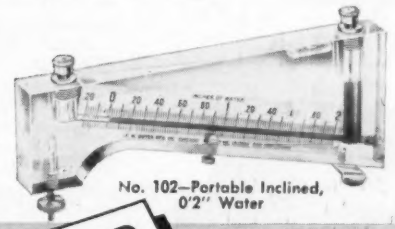

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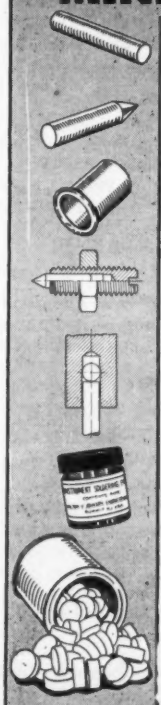
MINIATURE PARTS



CUSTOM MANUFACTURE OF SMALL PARTS

• Shafts, Staffs and Pivots of Special Pivot Steel, Heat-Treated and Metallographic-Polished. • Tubular Products up to ⅜" Diameter, Cut, Flared, Swaged, Formed and Burr-Free Alloy or Silver Plated. • Screw-Machine Products up to 3/16" Diameter. • Roll-Threading and Knurling to Close Tolerances. • Centerless and Surface Grinding with Special Facilities for Ceramic Rods and Shapes. • Light Punch-Press Work.

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Count

▶ BETTER
▶ LONGER
▶ FASTER

with

PIC-600

TWINS

50 million count life — conservative rating.

1000 counts per minute — higher speeds with suitable actuation.

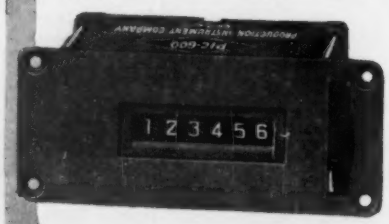
7 watts power consumption

Balanced armatures (for accurate performance on airborne equipment).

Quiet operation. No AC hum when energized.

Dust-resistant, tamper-proof housing. One-piece die-cast enclosure with close fitting cover secured with concealed screws.

Available in Basement and Standard-mount Models for 60, 40-50, and 25 cycles, also DC all voltages to 150.



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702 W. Jackson Chicago 6, Illinois

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New Literature...

For literature use the postage-free order card on page 1979

AUTOMATION

Boiler-Plant Instrumentation. New 24-page Catalog 55-605-83 presents maker's line of power plant instruments and combustion control systems, including draft gages; flow, level, temperature and pressure instruments; panels; and basic prototype systems.—Hays Corp., Michigan City, Ind.

Circle **516** on inquiry card.

Process Recorder-Controller. New 12-page Specification Sheet E12-4 describes maker's d-c potentiometric receiver-recorder and controller for temperature, pH, force, pressure, etc. —Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio.

Circle **517** on inquiry card.

Electro-Pneumatic Control. New 8-page Brochure ND4(8) describes maker's "Series 60" current-adjusting type control unit for electro-pneumatic control of process variables.—Leeds & Northrup Co., 4934 Stenton Ave., Phila. 44, Pa.

Circle **518** on inquiry card.

Instrumentation Index. New 28-page Bulletin 100-D is index of maker's literature. Index is broken down by subject, industry and product. Covers catalogs, bulletins, specification sheets, data sheets and articles from **Instrumentation** Magazine.—Industrial Div., Minneapolis-Honeywell Regulator Co., Phila. 44, Pa.

Circle **519** on inquiry card.

Process Control Center. New 4-page descriptive Bulletin 605-1 illustrates maker's "Panalog 605" dual-function information system featuring direct typed output of all process variables. —Panellit, Inc., 7401 N. Hamlin Ave., Skokie, Ill.

Circle **520** on inquiry card.

Air Conditioning Control. New 16-page booklet pictures and describes uses of maker's electronic controls for air conditioning.—Minneapolis-Honeywell Regulator Co., 2753 Fourth Ave. South, Minneapolis 8, Minn.

Circle **521** on inquiry card.

Process Instrumentation. New 22-page Technical Bulletin CAN-1 "Canning Industry Instrumentation" describes maker's instruments used in blanching, peeling, open kettle cooking, gravity separation, etc.—Industrial Div., — Minneapolis-Honeywell Regulator Co., Phila. 44, Pa.

Circle **522** on inquiry card.

Process Instrumentation. New 32-page issue of "Instrumentation" (Vol. 8, No. 2) features articles illustrating uses of maker's process instruments. Includes article on "Tuning" controller and process.—Industrial Div., M-Honeywell Regulator Co., Phila. 44, Pa.

Circle **523** on inquiry card.

Pneumatic Controllers. New 10-page Product Data Sheet A113 1 2-2 presents information on maker's "Series 650" Metagraphic pneumatic process controllers.—Bristol Co., Waterbury 20, Conn.

Circle **524** on inquiry card.

Metagraphic Control Instruments. New 4-page Bulletin A126 describes maker's Metagraphic process control instruments, recording receiver, controller, etc.—Bristol Co., Waterbury 20, Conn.

Circle **525** on inquiry card.

Pneumatic Transmission Instruments. New 6-page Bulletin W1827 describes maker's Metagraphic pneumatic transmission instruments.—Bristol Co., Waterbury 20, Conn.

Circle **526** on inquiry card.

Electric Process Controllers. New 4-page Bulletin 4-11 describes maker's line of electric proportional controllers for controlling dew point, pressure, temperature, etc.—Foxboro Co., Foxboro, Mass.

Circle **527** on inquiry card.

Saturable Reactors for Power Control. New 8-page Brochure GEA-6354 describes applications, models and ratings of maker's saturable reactors for versatile power control.—General Electric Co., Schenectady, N. Y.

Circle **528** on inquiry card.

Pneumatic Regulators. New 8-page Bulletin H-2 lists maker's complete line of precision-made pneumatic control equipment for process variables. —Conoflow Corp., 2100 Arch St., Phila. 3, Pa.

Circle **529** on inquiry card.

Servo System Analysis, Components. Three new Bulletins (TDS-1120-4, -2300, and -1110) describe maker's "Servoflex" amplifiers, "Servomation" building blocks and "Model 1110A Servoboard."—Servo Corp of America, New Hyde Park, N. Y.

Circle **530** on inquiry card.

Numerical Control of Machines. New 4-page illustrated Bulletin 591 describes maker's automatic method of translating data into machine positions.—Pratt & Whitney Div., West Hartford 1, Conn.

Circle **531** on inquiry card.

Pilot Plant. New 2-page data sheet describes maker's 15-gallon reaction-distillation pilot plant for experimentation in resin manufacturing and similar processes.—Patterson-Kelly Co., Inc., 10 Lackawanna Ave., E. Stroudsburg, Pa.

Circle **532** on inquiry card.

Supervisory Remote Control. New 4-page Bulletin 240-M6 describes maker's "Synchro-Scan" supervisory control for remote control of any combination of pumps, valves, gates, etc. from a central dispatching station. —Builders-Providence, Inc., Div. of B-I-F Industries, Inc., Providence 1, R. I.

Circle **533** on inquiry card.

INSTRUMENTS and AUTOMATION

Process Control. New 12-page Bulletin BIF-5 pictures and describes large line of flowmeters, feeders, and controllers for the process industries. —B-I-F Industries, Inc., Providence 1, R. I.

Circle **534** on inquiry card.

Punched-Tape Control System. New 8-page brochure pictures and describes maker's "Binotrol" punched tape control system for operating of milling machines, turret lathes, positioning tables, valves, etc.—Barnes Engineering Co., 30 Commerce Rd., Stamford, Conn.

Circle **535** on inquiry card.

Punched-Tape Machine Control. 12-page issue of "Techniques" (Fall '55) describes maker's "Binotrol" punched-tape control system for controlling turret lathes.—Barnes Engineering Co., 30 Commerce Rd., Stamford, Conn.

Circle **536** on inquiry card.

VALVES, CYLINDERS

Valve Selection Chart. New 18" x 24" valve selection chart provides data for selecting forged needle, bar stock and toggle valves.—Hoke, Inc., 231 S. Dean St., Englewood, N. J.

Circle **537** on inquiry card.

Valves. Three new 4-page Bulletins (A-5, W-5, and O-5) picture and describes maker's air, water and oil valves.—Barksdale Valves, 5125 Alcoa Ave., Los Angeles 58, Calif.

Circle **538** on inquiry card.

Solenoid Valve. New 2-page Bulletin 8210A solenoid valve used for controlling flow of liquids and gases in pipe lines.—Automatic Switch Co., 391 Lakeside Ave., Orange, N. J.

Circle **539** on inquiry card.

Valves. New 2-page Bulletin V5004 describes maker's 2-way solenoid valves.—Automatic Switch Co., 391 Lakeside Ave., Orange, N. J.

Circle **540** on inquiry card.

Valves. New loose-leaf catalog presents specifications, layout drawings and dimensions of maker's "R-S" butterfly valves.—S. Morgan Smith Co., York, Pa.

Circle **541** on inquiry card.

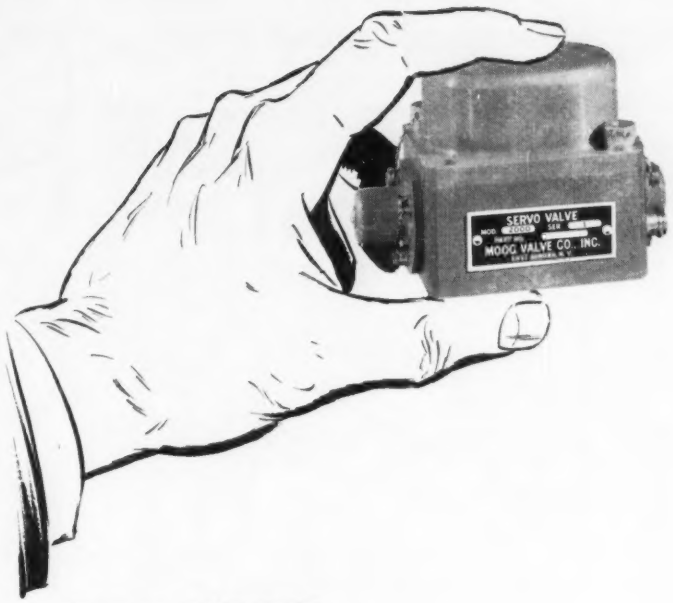
Valves, Strainers. New 2-page bulletin pictures and describes maker's valves, automatic interlocks, flow volume control and straight-line strainer. —Hays Mfg. Co., W. 12th St., Erie, Pa.

Circle **542** on inquiry card.

Solenoid Valves. New 4-page Brochure 101 pictures and describes maker's solenoid valves, "Models SV-2700-1, SV-2700-8"; and "SV-2700-16" sanitary valves.—Valcor Engineering Corp., Carnegie Ave., Kenilworth, N. J.

Circle **543** on inquiry card.

Pumps, Cylinders. New 36-page Catalog 555 presents specifications and applications of maker's pumps,



From MOOG . . .

a Dry Solenoid Servo Valve

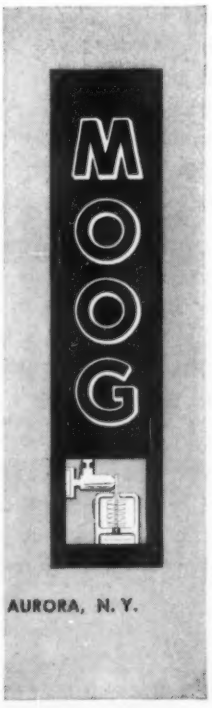
For those electro-hydraulic servo systems which require valves of high dynamic performance, reliability, small size and low weight, Moog units have achieved recognition as the industry standard.

And now, for those systems in which the fluid contains entrained iron, Moog has developed the Model 2000 Servo Valve. These units feature a dry solenoid which eliminates the possibility of torque motor contamination due to magnetic particles. These valves comply with requirements of MIL-H-5440A and are smaller and lighter than other Moog units of the same flow capacity.

Moog Valves, including Model 2000, are proportional type, electrically actuated, hydraulic, four-way valves featuring high dynamic response, sensitivity, linearity, and reliability. Production models are designed to operate in hydraulic systems of from 1000 to 3000 psi pressure. Rated output flows from 0.1 to 50.0 GPM for control currents of from 2.0 to 40.0 milliamperes as specified are available in production units.

Conventionally the valve input is from a balanced push-pull DC amplifier and the valve flow output is applied to a piston or hydraulic motor. An electric signal proportional to piston position or motor angular rotation is fed back to the amplifier to give a closed servo loop.

Typical applications for these units are in servo systems used for guided missile and aircraft flight controls, radar scanner actuation, contour following machine tools, and automatic packaging equipment.



For details write for Bulletin 2000-3

MOOG VALVE CO., INC. PRONER AIRPORT EAST AURORA, N. Y.

For more information circle **144** on inquiry card.

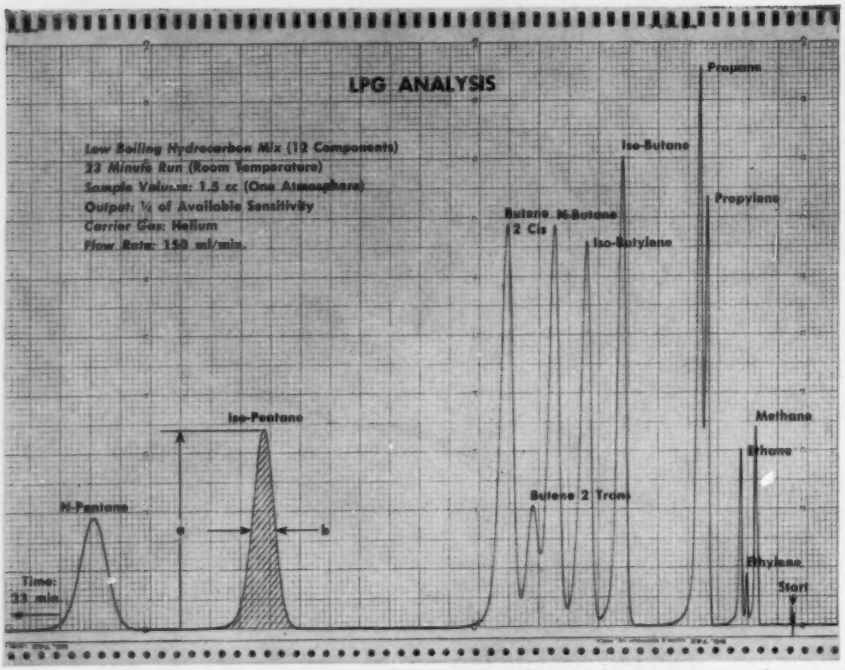


Photo of actual run made on new P-E Vapor Fractometer. To find mole % concentration of a component, analyst simply integrates area under peak by multiplying peak height (a) times half-band width (b).

This quantitative analysis took only 23 minutes on the new P-E Vapor Fractometer that costs only $1,375

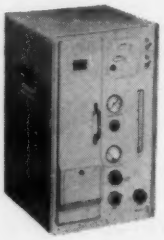
HOW LONG WOULD IT TAKE YOU?

Employing the principles of gas chromatography, P-E's new vapor fractometer is a revolutionary advance in the field of gas and volatile-liquid quantitative analysis. It is fast, precise, uncomplicated to operate, extremely simple in calculation, and above all, many times less expensive than distillation columns, mass spectrometer, or any other instrument, for the purpose.

For qualitative analysis, the instrument gives extremely clean separations—even of components and isomers which cannot be separated by ordinary methods. For trace analysis, high sensitivity permits use of extremely small samples.

Take, for example, the analysis of a synthetic LPG mix shown above. Here 12 components, representing the hydrocarbons most frequently encountered, were clearly separated—a job extremely difficult to accomplish by ordinary vacuum distillation methods. The perfect shape of the recorder bands makes quantitative analysis simple and accurate. Area under each peak is the measure of the mole % concentration of the component. These area relationships are all that is needed for calculation, without preliminary calibration for each individual component.

There is no faster, no simpler, no more inexpensive method in existence today.



This is the Model 154 Vapor Fractometer—price, $1375.00 without recorder. Send for descriptive bulletin.

Perkin-Elmer CORPORATION

Norwalk, Connecticut

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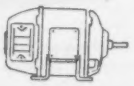
NEW LITERATURE

cylinders, jacks, braces, etc.—Star Jack Co., Inc., 430 Lexington Ave., New York 17, N. Y.

Circle **544** on inquiry card.

MOTORS, DRIVES



Eddy-Current Speed Drives. New 16-page Bulletin EC-1 presents principles, installation, performance and maintenance data on maker's "Dynamatic" speed-controlled rotating equipment.—Dynamatic Div., Eaton Mfg. Co., Kenosha, Wisc.

Circle **545** on inquiry card.

Motors. New 8-page 50th Anniversary issue of "Bodine Motorgram" presents history of the Bodine motor. —Bodine Electric Co., 2250 W. Ohio St., Chicago 12, Ill.

Circle **546** on inquiry card.

TEMPERATURE

Radiation Pyrometer. New 2-page Bulletin 9320 describes maker's high-speed "Radiamatic" detector that responds to temperature to 2600° F in less than ½ sec.—Industrial Div., Minneapolis-Honeywell Regulator Co., Philadelphia 44, Pa.

Circle **547** on inquiry card.

Temperature Control. New 2-page Data Sheet 1.2-2 describes maker's temperature control system for brick drying kilns.—Industrial Div., Minneapolis-Honeywell Regulator Co., Phila. 44, Pa.

Circle **548** on inquiry card.

Infrared Detectors. New 4-page Bulletin TDS-HDCA presents "Servotherm" infrared detection system, including preamp, power unit, and amplifier.—Servo Corp of America, New Hyde Park, N. Y.

Circle **549** on inquiry card.

Pyrometer. New 4-page Bulletin PT 556 presents specifications and dimensions on maker's photoelectric pyrometer "Type P2T".—Electronics Corp. of America, 77 Broadway, Cambridge 42, Mass.

Circle **550** on inquiry card.

Temperature Equipment. Three new Bulletins (10A, 102, and 12) describe maker's "TME" temperature measuring equipment, high-resistance temperature transducers, and presents specifications on thermocouple reference junction.—Arnoux Corp., 11924 W. Washington Blvd., Los Angeles, Calif.

Circle **551** on inquiry card.

PRESSURE

Pressure Conversion Chart. New Bulletin CEC 1557 presents CEC's pressure conversion chart and pressure conversion table.—Consolidated Engineering Corp., 300 N. Sierra Madre Villa, Pasadena 15, Calif.

Circle **552** on inquiry card.

Precision Electromanometer. New 4-page Bulletin 1547 pictures and describes maker's (Type 37-103) "Electromanometer" pressure-measuring instrument with 4-digit direct readout. Includes 2-page price list.—Consolidated Engineering Corp., 300 N. Sierra Madre Villa, Pasadena 15, Calif.

Circle **553** on inquiry card.

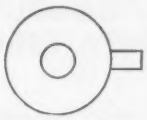
Pressure Gage. New 4-page Bulletin 364 presents specifications on maker's "Acragage" pressure gage.—Norden-Ketay Corp., Wiley St., Milford, Conn.

Circle **554** on inquiry card.

Pressure Transducers. Five new 2-page Bulletins MPT-1, 130, 131, and 132 describe maker's miniature pressure transducers; Bulletin PA-1 describes pressure adapter.—Statham Laboratories, Inc., 12401 W. Olympic Blvd., Los Angeles 64, Calif.

Circle **555** on inquiry card.

FLOW



Controlled-Volume Pumps. New 4-page Bulletin 955 describes maker's line of controlled-volume pumps for low-capacity flow control.—Milton Roy Co., 1300 E. Mermaid Lane, Phila. 18, Pa.

Circle **556** on inquiry card.

Rotameter. New 2-page bulletin pictures and describes maker's "Style FR" variable-area rotameter.—Jacoby-Tarbox Corp., 808 Nepperhan Ave., Yonkers, N. Y.

Circle **557** on inquiry card.

Fuel Gage Calibrator. New 8-page issue of "Experimenter" (Vol. 30, No. 4) describes calibrator for aircraft fuel gages.—General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

Circle **558** on inquiry card.

Insert Nozzle. New 4-page Bulletin 130-K3A pictures and describes maker's "Model NZIF" Venturi insert nozzle for main line metering.—Builders-Providence, Inc., Providence, R. I.

Circle **559** on inquiry card.

Pump, Feeder. New 2-page Bulletin 50-K7A describes maker's "Vitamiser" (Model 50A) disc feeder for feeding vitamin concentrates, bleach, malt and bromate, micronutrients, etc.—Omega Machine Co., Div. of B-I-F Industries, Inc., Providence 1, R. I.

Circle **560** on inquiry card.

AIR, MOISTURE

Air Filters, Dryers. New 4-page Bulletin M-7155 describes and illustrates maker's "Model M-30" and "Model M-100 Condensifilters" for instrument-quality compressed air.—Hankison Corp., 951 Banksville Rd., Pgh. 16, Pa.

Circle **561** on inquiry card.

Moisture. New 6-page Brochure 101-56 describes maker's "Hygrotester" for indicating and recording % H_2O.—Hygrotester, Inc., P. O. Box 923, Brooklyn 1, N. Y.

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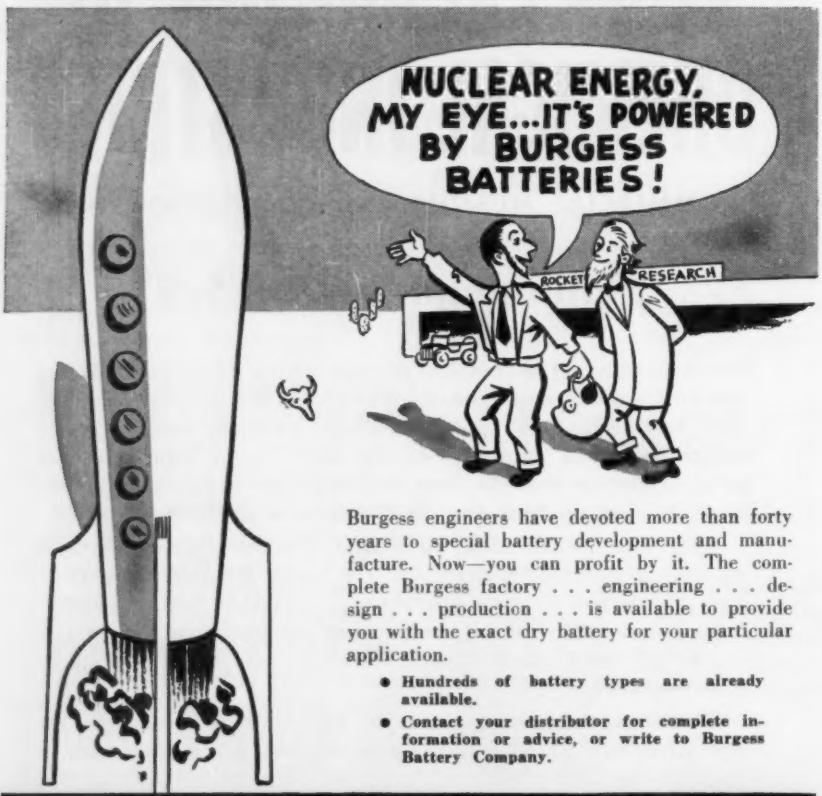

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NEW LITERATURE

Moisture Control. New 4-page Bulletin 9311 describes maker's "Moist-O-Graph" moisture controller-recorder in a pedestal mounted cubicle.—Minneapolis-Honeywell Regulator Co., Industrial Div., Phila. 44, Pa.

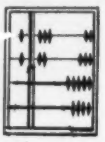
Circle **563** on inquiry card.

POSITION

Position Control System. New Automation Engineering Bulletin V-4003 describes maker's positioning control system for positioning test models in blowdown tunnels.—CDC Control Services, Inc., 400 S. Warminster Rd., Hatboro, Pa.

Circle **564** on inquiry card.

COMPUTING, DATA REDUCTION



Data Processing System. New 16-page issue of "CEC Recordings" (Vol. 9, No. 4) describes maker's "Data-Tape" system which permits airborne recording of test data.—Consolidated Engineering Corp., 300 N. Sierra Madre Villa, Pasadena 15, Calif.

Circle **565** on inquiry card.

Computers. New 6-page issue of "Rea-Letter No. 2" presents a progress report on Rea developments in computing and data processing fields.—J. B. Rea Co., 1723 Cloverfield Blvd., Santa Monica, Calif.

Circle **566** on inquiry card.

Simulators, Computers. New 4-page bulletin describes maker's special-purpose simulators, analog computers, and servomechanisms.—Newton Co., 55 Elm St., Manchester, Conn.

Circle **567** on inquiry card.

TIME, COUNT

Cycle Timer. New 2-page Bulletin 755 describes and illustrates maker's "Model 4" electronic cycle timer.—G. C. Wilson & Co., Huntington, W. Va.

Circle **568** on inquiry card.

Electronic Counters. Four new 2-page bulletins picture and describe maker's "WE-210" time interval meter, "WE-110" frequency indicator and electronic counter, "WE-310" preset counter and "WE-710" miniature electronic counters.—Westport Electric, 149 Lomita St., El Segundo, Calif.

Circle **569** on inquiry card.

Counters. Two new 2-page bulletins describe maker's "Model U281ERS" automatic cycling predetermining counters and "Model F28OERS" automatic predetermining impulse counters.—Presin Co., 802 N. Fairfax Ave., Los Angeles 46, Calif.

Circle **570** on inquiry card.

RECORDING

Tape Recorder. New 26-page Bulletin 1561A describes and illustrates maker's "Datatape" recording and playback system for recording stress,

pressure, temperature and vibration. —Consolidated Engineering Corp., 300 N. Sierra Madre Villa, Pasadena, Calif.

Circle **571** on inquiry card.

Oscillograph. New 12-page Bulletin 1521B describes maker's "Type 5-116" multi-channel recording oscillograph. —Consolidated Engineering Corp., 300 N. Sierra Madre Villa, Pasadena 15, Calif.

Circle **572** on inquiry card.

Galvanometers. New 2-page Bulletin CEC-1559 describes maker's "Series 7-300" recording galvanometers. Includes 2-page price list.—Consolidated Engineering Corp., 300 N. Sierra Madre Villa, Pasadena 15, Calif.

Circle **573** on inquiry card.

Recording Oscillograph, Converter Power Supply. Three 2-page Bulletins (1562, CEC-1560, CEC-1543A) describe maker's "Types 3-120A and 3-132", 26-v power supplies for oscillographs; "Type 8-110" 4-channel bridge balance for coupling strain gages and resistive pickups to recording oscillographs. Includes two 2-page price lists. —Consolidated Engineering Corp., 300 N. Sierra Madre Villa, Pasadena 15, Calif.

Circle **574** on inquiry card.

Oscillograph. New 16-page issue of "Oscillographer" (Vol. 15, No. 3) features article on "Cathode-ray Oscillograph Display System for Use With High-speed Electronic Computers."—Allen B. DuMont Labs., Inc., 760 Bloomfield Ave., Clifton, N. J.

Circle **575** on inquiry card.

Cathode-Ray Equipment. New 2-page bulletin describes maker's oscillographs, recording cameras, and accessories.—Allen B. DuMont Labs., Inc., 760 Bloomfield Ave., Clifton, N. J.

Circle **576** on inquiry card.

RADIOACTIVITY

Ionization Chambers. New 46-page Bulletin NER-1 presents technical data on maker's d-c ionization chambers and measurement of nuclear radiation. —Industrial Div., Minneapolis-Honeywell Regulator Co., Philadelphia 44, Pa.

Circle **577** on inquiry card.

Reactor Simulator. New 4-page Folder ND46-70-700(2) describes maker's nuclear reactor simulator.—Leeds & Northrup Co., 444 N. 16th St., Phila. 30, Pa.

Circle **578** on inquiry card.

Fission Products. New 102-page report to U. S. Atomic Energy Commission covers industrial uses of radioactive fission products. Price $1.50.—Stanford Research Institute, Stanford, Calif.

Circle **579** on inquiry card.

Soft Beta Emitters. New 24-page booklet is article on "Counting Soft Beta Emitters with Liquid Phospher Techniques."—Technical Measurement Corp., 140 State St., New Haven 11, Conn.

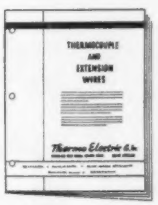
Circle **580** on inquiry card.

RADIOGRAPHY

X-Ray Inspection. New 6-page leaflet describes maker's "Andrex" port-

Here's how a reel of T-E wire looks after you unwrap it. The easy-to-read label can save valuable time when you must know, and know quickly, what kind of wire is on the reel. The label tells you not only wire type, length, and polarity, but insulation colors too. Therefore, you can identify conductors easily by comparing colors listed on the label with those on the wire itself.

As you can see, it's a well-thought-out label. Important by itself, it's also a revealing illustration of the care T-E takes. Thoroughness is characteristic of every step in T-E's wire production, from drawing and calibrating to insulating. The result of such care is a product which meets high industrial standards.



There are too many T-E wires to mention comfortably in one ad. However, in T-E's 8-pg. Wire Bulletin you can see insulations, gages, and calibrations, as well as charts with calibration symbols, color codes, insulation characteristics, resistances, weights, electrical properties, and conduit capacities. Write for Bulletin 31-F.

Pyrometers • Thermocouples • Protection Tubes • Quick-Coupling Connectors
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Thermo Electric Co., Inc.
SADDLE RIVER TOWNSHIP, ROCHELLE PARK POST OFFICE, NEW JERSEY
IN CANADA—THERMO ELECTRIC (Canada) Ltd., BRAMPTON, ONTARIO

For more information circle **149** on inquiry card.

Phase Measurement
IN
QUALITY CONTROL —
BELL AIRCRAFT USES
TIC'S DIRECT READING PHASE METERS
MAGNETIC MODULATOR BIAS
Operating bias in magnetic modulators accurately set with TIC's Type 320-AB Phase Meter. Modulators are in helicopter vertical height control computers.
to speed production and unit inspection in the Buffalo, New York, plant.
Adjustments and performance tolerance limits are quickly and accurately established by Bell's production personnel with TIC's Phase Meters for on-the-line inspection of:
AUTO PILOT AMPLIFIERS
Autopilot-amplifier phase shift measured and adjusted to exacting tolerances with TIC's Type 320AB Phase Meter. Amplifiers control helicopter roll, pitch, yaw and vertical height.
SYNCHRO PHASING
Helicopter Autopilot Gyro Table Assembly undergoes precise synchro phasing and connection identification. Assembly is quickly checked on a calibrated positional test table with 320AB Phase Meter.
INITIAL SYNCHRO PHASE SHIFT
Inherent phase shift between rotor and stator winding of synchros must be determined and held rigorously within small tolerances. Phase shift is displayed on TIC Type 320AB Phase Meter.
RESONANT FREQUENCY
Resonant frequency of accelerometers measured with TIC's Type 322-A Phase Meter. Meter locates frequency that produces 90° phase shift between electrical output and mechanical input. Steepness of phase curve at resonance, makes this method much more accurate than determining frequency yielding highest output amplitude.
TIC'S PHASE METERS
DIRECT READING TIC Phase Meters permit production-line testing of vital phase characteristics. Phase meters can be used for sine wave or for complex wave inputs having one positive going zero-axis crossing per cycle. Write for free brochure I-104 for data on TIC's complete line of phase instruments.
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West Coast Mail Address: P.O. Box 3941, North Hollywood, Calif., POplar 5-8620

For more information circle **150** on inquiry card.

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NEW LITERATURE

able lightweight x-ray units.—Holger Andreasen, Inc., 703 Market St., San Francisco 3, Calif.

Circle **581** on inquiry card.

Radiography, Projectors. New 24-page booklet describes maker's "Kel-Ray" portable gamma ray projector used in industrial radiography.—Metal & Thermit Corp., 100 E. 42nd St., New York 17, N. Y.

Circle **582** on inquiry card.

TESTING

Testing Instruments. New 46-page catalog illustrates and describes maker's tensile testers, tachometers, indicators, strength testers, etc.—Amthor Testing Instrument Co., Inc., 45-53 Van Sinderen Ave., Brooklyn 7, N. Y.

Circle **583** on inquiry card.

Temperature Cabinet. New 2-page Bulletin 339 describes and illustrates maker's dual-range low-temperature cabinet.—Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.

Circle **584** on inquiry card.

Soil Testing. New 4-page Bulletin A-12 pictures and describes maker's soil moisture and fertility measuring equipment. — Industrial Instruments, Inc., 89 Commerce Rd., Cedar Grove, N. J.

Circle **585** on inquiry card.

Concrete Tester. New 6-page leaflet pictures maker's "Model CT-711" concrete tester.—Soiltest, Inc., 4711 W. North Ave., Chicago 39, Ill.

Circle **586** on inquiry card.

Fatigue Testing. New 6-page folder describes maker's "Ivy-12" multi-range fatigue testing machine.—Ivy Co., Norwalk, Conn.

Circle **587** on inquiry card.

STRAIN, VIBRATION

Strain Gages. New 8-page Bulletin CEC-1563 features article on principles of strain gages.—Consolidated Engineering Corp., 300 North Sierra Villa, Pasadena, Calif.

Circle **588** on inquiry card.

Vibration Handbook. New 60-page illustrated booklet "Measurement of Vibration," principles of motion—velocity — acceleration — vibration, includes analyzers for important variables and analysis of problems. Also described are maker's vibration-measuring instruments.—General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

Circle **589** on inquiry card.

Vibration Testing. New 8-page issue of "MB Vibration Notebook" (Vol. 1, No. 2) features article on problems involved in developing vibration test procedures for guided-missile testing. —MB Manufacturing Co., Inc., 1060 State St., New Haven, Conn.

Circle **590** on inquiry card.

Displacement, Vibration. New 10-page pamphlet describes maker's "Optron" for measuring displacement, runout or vibration of oscillating or rotating parts.—Optronic Co., 136 Caputo Lane, San Jose, Calif.

Circle **591** on inquiry card.

Vibration Control. New 8-page Catalog G-55 illustrates and describes maker's "Spring-Flex" vibration control mountings.—Vibration Mountings, Inc., 76-17 Queens Blvd., Elmhurst, N. Y.

Circle **592** on inquiry card.

OPTICS

Surface Mirrors. New 8-page brochure describes maker's surface mirrors, beam splitters and evaporated first surface coatings.—Evaporated Metal Films Corp., 147 E. State St., Ithaca, N. Y.

Circle **593** on inquiry card.

Optical Coating. New 16-page leaflet presents executive staff and manufacturing facilities for precision optics. —Optical Coating Laboratory, Inc., Santa Rosa, Calif.

Circle **594** on inquiry card.

ITV

TV Equipment. New 4-page Booklet ECL-21 presents specifications and applications of maker's closed-circuit television equipment.—General Electric Co., Electronics Park, Syracuse 1, N. Y.

Circle **595** on inquiry card.

TV Systems. New 12-page Booklet IM-55 describes maker's multiple and industrial TV systems.—Blonder-Tongue Labs., Westfield, N. J.

Circle **596** on inquiry card.

DIMENSIONAL

Comparators. New 24-page Brochure 586 describes maker's "Models F, G, and H Air-O-Limit" comparators.—Pratt & Whitney Div., West Hartford 1, Conn.

Circle **597** on inquiry card.

Dimensional Gaging Machines. New 12-page Booklet 592 describes maker's "Sigmatic" multi-dimension gaging machines.—Pratt & Whtiney Div., West Hartford 1, Conn.

Circle **598** on inquiry card.

Dimensional Gages. New 8-page pamphlet pictures and describes broad variety of maker's gages for measurement control, including plug gages, ring gages, air gages, snap gages, etc. —Freeland Gauge Co., 9940 Freeland Ave., Detroit 27, Mich.

Circle **599** on inquiry card.

ANALYTICAL

Refractometer. New 8-page Bulletin 1839 describes maker's "Type 38-201" process refractometer.—Consolidated Engineering Corp., 300 N. Sierra Madre Villa, Pasadena 15, Calif.

Circle **600** on inquiry card.

Gas Analyzer. New 2-page Data Sheet 10.15-14 presents application of maker's "Electronik" controller in use with "Gow-Mac" thermal-conductivity-type gas analyzers.—Industrial Div., Minneapolis-Honeywell Regulator Co., Phila. 44, Pa.

Circle **601** on inquiry card.

Gas Analyzers. New 8-page issue of "Analyzer" (Vol. 1, No. 2) features article "Rigid Tests Insure Quality Instruments".—Liston-Becker Instrument Co., Inc., Springdale, Conn.

Circle **602** on inquiry card.

Gas Detector. New 2-page Bulletin G-755 describes maker's portable de-

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ALINA KNURL CUTTERS actually mill the pattern and produce chips in the process. Alina Knurl Cutters will cut your machining time approx. 30%. They will provide the solution to some of your most complex knurling problems.

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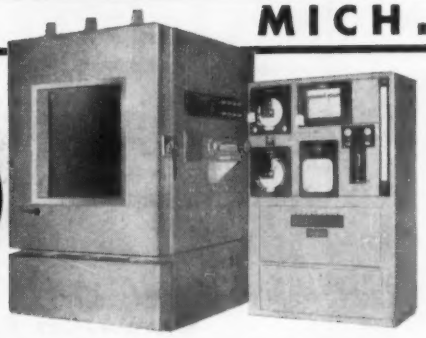

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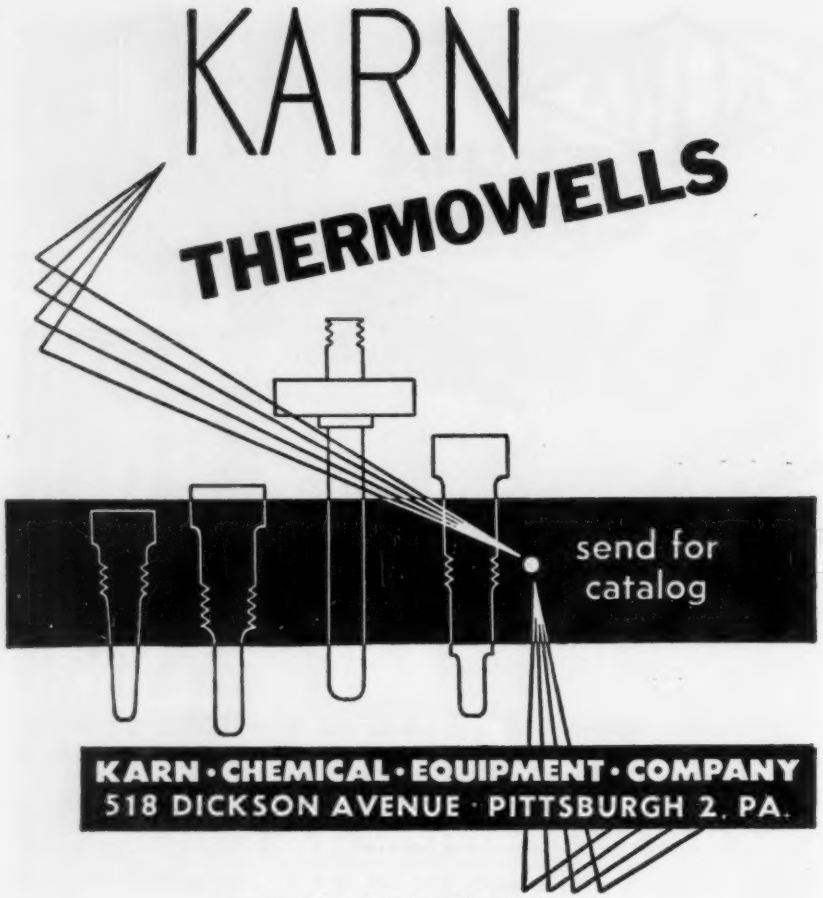

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For more information circle **155** on inquiry card.

NEW LITERATURE

tector for combustible gas explorations.—Johnson-Williams, Inc., Palo Alto, Calif.

Circle **603** on inquiry card.

Spectrometers. New 8-page folder describes maker's spectrometer for analyzing metals and non-metallic substances.—Baird Associates, Inc., 33 University Rd., Cambridge, Mass.

Circle **604** on inquiry card.

Grating Monochromators. New 4-page Bulletin 811 pictures maker's grating monochromators for ultraviolet and visible ranges.—Farrand Optical Co., Inc., Bronx Blvd. and E. 238th St., New York 70, N. Y.

Circle **605** on inquiry card.

pH Meter. New 4-page Bulletin 118 pictures maker's "Model 125" pH meter for laboratory and plant use.—Photovolt Corp., 95 Madison Ave., New York 16, N. Y.

Circle **606** on inquiry card.

pH Meter. New 4-page brochure describes maker's "Model 110" line-operated electronic pH meter.—Photovolt Corp., 95 Madison Ave., New York 16, N. Y.

Circle **607** on inquiry card.

LAB APPARATUS

Laboratory Instruments. New 16-page booklet "What's New for the Laboratory" pictures and describes laboratory instruments. Includes 6-page insert on new line of "Ohaus" Harvard trip balances. — Scientific Glass Apparatus Co., Inc., Bloomfield, N. J.

Circle **608** on inquiry card.

Gas Chromatography. New 12-page Booklet 83 describes maker's "Kromo-Tog" instrument for analysis of gases and liquids by gas chromatography.—Burrell Corp., 2223 Fifth Ave., Pgh. 19, Pa.

Circle **609** on inquiry card.

Rheometers, Gelometers. New 8-page Bulletin 330 presents maker's line of rheometers, process units, and auxiliary equipment for processing and control of dispersions, polymers and lubricants.—Burrell Corp., 2223 Fifth Ave., Pgh. 19, Pa.

Circle **610** on inquiry card.

Vacuum Oven. New 2-page Bulletin 377 describes maker's "Model 19" vacuum oven used for drying organic materials, conditioning and annealing.—Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.

Circle **611** on inquiry card.

Lab Circulating System. New 2-page Bulletin 660 describes and illustrates maker's "Temp-Trol" constant temperature circulating system for heating or cooling refractometer.—Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.

Circle **612** on inquiry card.

Laboratory Instruments. New 4-page describes and illustrates maker's "Thermotrol" and "Resistotrol" temperature controllers, "Manostat" pressure controller, flow meters, viscom-

eters, etc.—Hallikainen Instruments, 1341 Seventh St., Berkeley 10, Calif.
Circle **613** on inquiry card.

Bottle Pump. New 2-page Bulletin 136 describes maker's bottle pump which pumps out distilled water from tank or carboy permitting only purified air to enter.—Barnstead Still & Sterilizer Co., 243 Lanesville Terrace, Forest Hills, Boston 31, Mass.
Circle **614** on inquiry card.

Distilled Water Heater. New 2-page Bulletin 132 describes maker's distilled-water heater.—Barnstead Still & Sterilizer Co., 243 Lanesville Terrace, Forest Hills, Boston 31, Mass.
Circle **615** on inquiry card.

Glassware, Packaging. New 4-page bulletin describes maker's "Air-Pak" packaging program for laboratory glassware.—Doerr Glass Co., Vineland, N. J.
Circle **616** on inquiry card.

MAGNETICS

Electrical Laminations. New 40-page Bulletin L-355 presents all basic characteristics of maker's electrical laminations for industrial applications.—Thomas & Skinner Steel Products, Inc., Indianapolis 7, Ind.
Circle **617** on inquiry card.

Magnetic Shields. New 36-page Catalog MS-104 "Performance-Guaranteed Magnetic Shields" describes maker's shield alloys, including annealing process used for controlling properties, fabrication, and finishes.—Magnetics, Inc., Butler, Pa.
Circle **618** on inquiry card.

Magnets. New 4-page Catalog 15 describes maker's "Indox 1" ceramic permanent magnets.—Indiana Steel Products Co., Valparaiso, Ind.
Circle **619** on inquiry card.

Magnetic Drums for Material Separation. New 6-page illustrated Bulletin MD-200 presents applications and features of maker's permanent-magnetic drums.—Homer Mfg. Co., Inc., Lima, Ohio.
Circle **620** on inquiry card.

ELECTRICAL, ELECTRONIC INSTRUMENTS

Electronic Equipment. New 256-page Catalog 62 pictures and describes line of adapters, connectors, decade boxes, electrical accessories, transistors, tuners, converters, etc.— Newark Electric Co., 223 W. Madison St., Chicago 6, Ill.
Circle **621** on inquiry card.

Electronic Equipment. New 324-page 1956 Catalog 150 presents complete list of electronic tubes, test instruments, voltage stabilizers, transformers, resistors, capacitors, switches, rectifiers, fuses, tools, cable, etc.—Allied Radio Corp., 100 N. Western Ave., Chicago 80, Ill.
Circle **622** on inquiry card.

VTVM. New 8-page Brochure I-105 describes maker's "Type 800A and 800B" vacuum tube voltmeters. Includes 6-page Laboratory Report 16 "Basic Theory of the Type 300A Vacuum Tube Voltmeter."—Technology Instrument Corp., 531 Main St., Acton, Mass.
Circle **623** on inquiry card.

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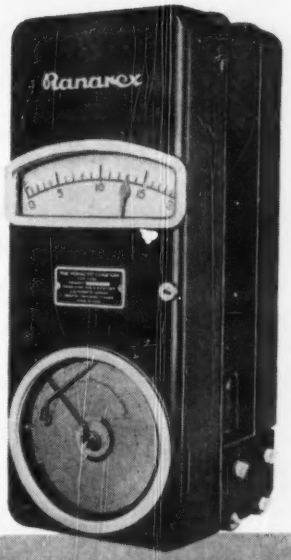

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Meter readers now can flip a switch on a DAGE TV monitor and read gauges, meters, dials and other indicators located in hard-to-get-at places. With a DAGE closed-circuit TV camera trained on recording instruments, all indicator readings can be made easily, quickly and accurately.

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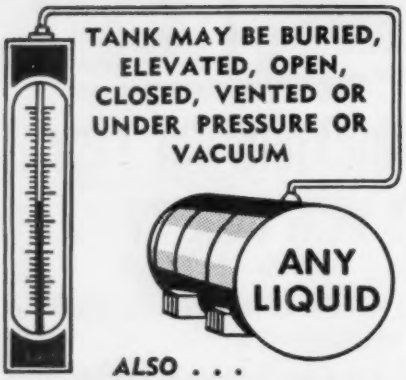

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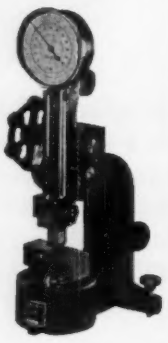


The Shore Instrument & Mfg. Co., Inc.

90-35 Van Wyck Expressway
Jamaica 35, N. Y.

For more information circle **160** on inquiry card.

NEW LITERATURE

Frequency Meter. New 4-page issue of "Hewlett-Packard Journal" (Vol. 7, No. 1) features article "A New 3 CPS-100 KC Electronic Frequency Meter with Discriminator Output and Expandable Scale."—Hewlett-Packard Co., 275 Page Mill Rd., Palo Alto, Calif.

Circle **624** on inquiry card.

Potentiometer. New 4-page Data Sheet E-51(3) describes maker's "Type K-2" potentiometer for instrument checking, temperature measurements, etc.—Leeds & Northrup Co., 4934 Stenton Ave., Phila. 44, Pa.

Circle **625** on inquiry card.

Electrical Indicator. New 2-page Data Sheet 10.02a presents specifications of the "Brown-Rubicon" precision electrical (mv) indicator with sensitivity of 1 microvolt.—Industrial Div., Minneapolis-Honeywell Regulator Co., Phila. 44, Pa.

Circle **626** on inquiry card.

Test Instruments. New 8-page brochure describes maker's line of electronic test instruments — VTVM's, oscillators, amplifiers, etc.—Shasta Div., Beckman Instruments, Inc., P. O. Box 296, Station A., Richmond, Calif.

Circle **627** on inquiry card.

Oscilloscopes. Four new bulletins describe and illustrate maker's large screen oscilloscopes and frequency generator. Includes 2-page price list.—Electromec, Inc., 5121 San Fernando Rd., Los Angeles 39, Calif.

Circle **628** on inquiry card.

Sine, Pip Generator. New 2-page Leaflet GPM-3 describes maker's sine and pip generator for radar instrumentation.—Dalmotor Co., 1342 Clay St., Santa Clara, Calif.

Circle **629** on inquiry card.

POWER SUPPLIES

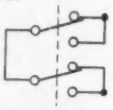
Hi-V Power Supplies. New 2-page Bulletin 131 presents electrical and mechanical features of maker's high-voltage power supplies.—Bracke-Seib X-Ray Co., 16 Pelham Bay Park W., Pelham Manor, N. Y.

Circle **630** on inquiry card.

Power Supply. New 2-page Bulletin G125-25A describes maker's "Model G 125-25" germanium rectifier power supply.—Perkin Engineering Corp., 345 Kansas St., El Segundo, Calif.

Circle **631** on inquiry card.

RELAYS, SWITCHES



Magnetic Starters. New 8-page illustrated Bulletin GEA-6301 describes maker's magnetic starters for air conditioning and refrigeration equipment.—General Electric Co., Schenectady 5, N. Y.

Circle **632** on inquiry card.

Limit Switches. New 8-page Bulletin GEA-6131A describes maker's limit switches for controlling machine tools, motor-operated doors, automatic conveyors, etc.—General Electric, Schenectady 5, N. Y.

Circle **633** on inquiry card.

Actuators, Switches. New 2-page Data Sheet P99 pictures and describes

maker's 4MA and 5MA push button actuators. Data Sheet 106 describes plastic encased switches for domestic appliances.—Micro Switch Div., Minneapolis-Honeywell Regulator Co., Freeport, Ill.

Circle **634** on inquiry card.

Relays. New 4-page illustrated brochure describes maker's subminiature relays for high-precision applications. —Elgin-Neomatic, Inc., 2435 N. Naomi St., Burbank, Calif.

Circle **635** on inquiry card.

Switches. New 8-page issue of "Helinews" (No. 10) describes maker's "Switchpot" switches.—Helipot Corp., S. Pasadena, Calif.

Circle **636** on inquiry card.

Telephone Switchboard. New 2-page Bulletin TEL-120 describes maker's "Model 4A23" dial telephone switchboard.—Telecom, Inc., 1019 Admiral, Kansas City 6, Mo.

Circle **637** on inquiry card.

Relays. New 4-page illustrated Bulletin SD-1 describes maker's "Agastat" time delay relays. Bulletin SR-6R describes "Model NEL" time delay relay.—A'G'A Div., Elastic Stop Nut Corp. of America, Elizabeth, N. J.

Circle **638** on inquiry card.

Switches. New 4-page issue of "Uses Unlimited" (Vol. 9, No. 3) describes maker's illuminated push-button switch.—Micro Switch Div., Minneapolis-Honeywell Regulator Co., Freeport, Ill.

Circle **639** on inquiry card.

Timers, Relays, Test Equipment. New 114-page engineering design brochure presents specifications of maker's current production items: including voltage regulators, timers, relays, test equipment, etc.—Electronic Specialty Co., Contract Div., 5121 San Fernando Rd., Los Angeles 39, Calif.

Circle **640** on inquiry card.

Mercury Switches. New 2-page bulletin pictures and describes maker's mercury switches and excitor lamps. —Almo Mfg. Co., 47 Washington St., Newark, N. J.

Circle **641** on inquiry card.

Welding Relays. New 2-page Bulletin 1054-151S describes maker's coilless type relays for continuous welding operations.—Automatic Switch Co., 391 Lakeside Ave., Orange, N. J.

Circle **642** on inquiry card.

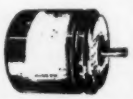
Electronic Relay. New 2-page Bulletin 214S presents applications and developments of maker's electronic relay.—Automatic Switch Co., 391 Lakeside Ave., Orange, N. J.

Circle **643** on inquiry card.

Rotary Solenoids. New 2-page "Ledex Engineering Sketchbook" Bulletin 10 features article on "Automatic Meter Range Selecting With Ledex." —G. H. Leland, Inc., Dayton 2, Ohio.

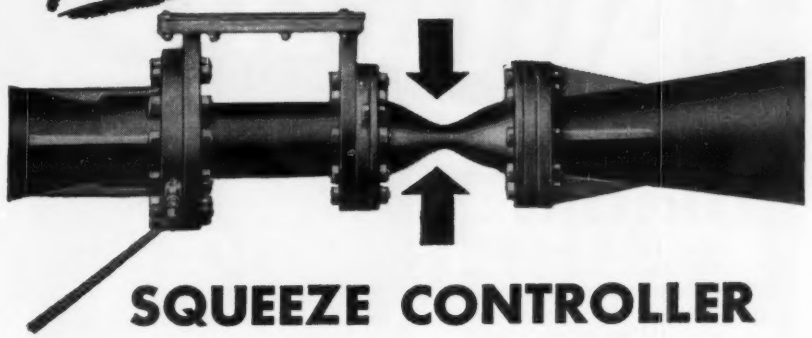
Circle **644** on inquiry card.

RESISTORS, POTENTIOMETERS



Potentiometer Instruments. New 4-page leaflet describes maker's potentiometer instruments used in aircraft, telemetering networks, and recording circuits. Includes linear-motion potentiometers, pressure-actuated po-

New! **SIMPLEX**



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NEW LITERATURE

tentiometers, acceleration-actuated potentiometers, etc.—Bourns Laboratories, 6135 Magnolia Ave., Riverside, Calif.

Circle **645** on inquiry card.

Resistors. Six new bulletins (P-1a, P-2a, F-3, B-2a, B-8a and 1055-1956 resistor engineering guide) present data on maker's "Types PW-4, PW-7, PW-10, HFR, MW," and ½-watt molded boron-carbon "precistors."—International Resistance Co., 401 N. Broad St., Phila. 8, Pa.

Circle **646** on inquiry card.

Potentiometer. New 4-page brochure describes maker's 400 cycle "Vernistat" a-c potentiometer used in servo systems and analog computers.—Perkin-Elmer Corp., Norwalk, Conn.

Circle **647** on inquiry card.

Negative-resistance Devices. New 20-page issue of "Cornell-Dubilier Capacitor" features article on "Negative Resistance Devices."—Cornell-Dubilier Electric Corp., Hamilton Blvd., S. Plainfield, N. J.

Circle **648** on inquiry card.

TUBES, TRANSISTORS

Transistors. Four new 2-page Bulletins DLS-545, 546, 547 and 548 describe maker's "Types 2N124, 2N125, 2N126 and 2N127" germanium switching transistors.—Texas Instruments, Inc., 6000 Lemmon Ave., Dallas 6, Tex.

Circle **649** on inquiry card.

Transistors. New 2-page Bulletin ECG-87 presents specifications on maker's "Type 2N107 PNP" junction transistors.—General Electric, Electronics Park, Syracuse, N. Y.

Circle **650** on inquiry card.

Junction Diodes. Ten new 2-page data sheets present mechanical and electrical data on maker's "Types 1N301, 1N302, 1N303, 1N432, 1N433, 1N434, 1N436, 1N437, 1N438 and 1N439" silicon junction and voltage regulator diodes.—Raytheon Mfg. Co., Newton 58, Mass.

Circle **651** on inquiry card.

Industrial Electron Tubes. New 20-page Booklet RIT-140 presents technical data on maker's industrial tubes—computer tubes, thyratrons, etc. Price $.20.—Radio Corp of America, Harrison, N. J.

Circle **652** on inquiry card.

Electron Tubes. New 20-page Brochure A1-55-10M presents description and price of maker's electron tubes. Includes about 1000 types—counter tubes, gas tubes, klystrons, phototubes, etc.—Industro, Inc., 649 Broadway, New York 12, N. Y.

Circle **653** on inquiry card.

Transistors. New 8-page leaflet presents article on theory and application of junction transistors.—Motorola, Inc., 4545 W. Augusta Blvd., Chicago 51, Ill.

Circle **654** on inquiry card.

CONNECTORS

Connectors. New 8-page issue of "Amphenol Engineering News" (Vol.

8, No. 5) describes maker's breakaway torpedo connectors.—American Phenolic Corp., 1830 54th Ave., Chicago 50, Ill.

Circle **655** on inquiry card.

Connectors, Components. New 16-page issue of "This Month" (Sept. 1955 Oct.) pictures and describes altitude controller, chokes, tube tester, contactors, connectors, etc.—Herbach & Rademan, Inc., 1204 Arch St., Phila. 7, Pa.

Circle **656** on inquiry card.

Connectors. New 22" x 27" wall chart presents selection of AN connectors.—Deutsch Co., 7000 Avalon Blvd., Los Angeles 3, Calif.

Circle **657** on inquiry card.

Connectors. New 2-page bulletin presents specifications on maker's "Series GS" rectangular precision connectors.—DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y.

Circle **658** on inquiry card.

Connectors. New 12-page Bulletin PM-1 "Methods of Potting Cannon Plugs" presents potting procedures with data on maker's connectors used for potting applications.—Cannon Electric Co., 422 W. Ave. 33, Los Angeles 31, Calif.

Circle **659** on inquiry card.

Coax Couplers. Two new 2-page Catalog Sheets 282, 302 describe maker's coaxial directional couplers and coaxial terminations for terminating directional couplers and test instruments.—Narda Corp., 160 Herricks Rd., Mineola, N. Y.

Circle **660** on inquiry card.

CAPACITORS

Capacitors. New 16-page Catalog 823 describes and illustrates maker's capacitors, including midget, single and dual, u.h.f. transmitting, etc.—Allen D. Cardwell Electronics Productions Corp., Plainville, Conn.

Circle **661** on inquiry card.

Tubular Capacitors. New 6-page Engineering Bulletin XC-201-4 presents information on maker's high-temperature "165 C XC" plastic film, dielectric, hermetically sealed tubular capacitors.—Gudeman Co., 340 W. Huron St., Chicago 10, Ill.

Circle **662** on inquiry card.

Capacitors. New 2-page catalog sheet presents maker's line of ultra-high-stability Polystyrene dielectric capacitors.—Corson Electric Mfg. Corp., 540 39th St., Union St., N. J.

Circle **663** on inquiry card.

MECHANICAL COMPONENTS

Ball Bearings. New 24-page catalog presents specifications on maker's miniature ball bearings.—Miniature Precision Bearings, Inc., Precision Park, Keene, N. Hampshire.

Circle **664** on inquiry card.

Steel Tubing—Fitting Load Limits. New series of charts show variation of load at yield of "Type 304" stainless steel tubing when held by maker's "Swagelok" tube fittings.— Crawford Fitting Co., 884 E. 140th St., Cleveland 10, Ohio.

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The names of these new Emil Greiner flowmeters tell the whole story. We believe they are the most important development in flowmeters since the invention of the rotameter. Now you can obtain complete predictability for all fluids!

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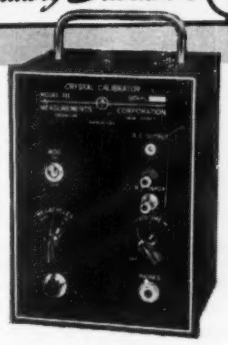

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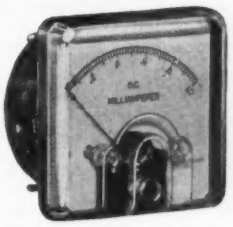

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Atomic Exposition, Booth 423, Dec. 10-16, Cleveland, Ohio.

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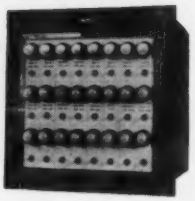

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NEW LITERATURE

Analytical-grade Resins. New 4-page Price List "L" presents two new products: analytical grade chromatographic alumina and anion exchange resins.—Bio-Rad Labs., 800 Delaware St., Berkeley, Calif.

Circle **666** on inquiry card.

Ceramic Pipes, Fittings. New 16-page Bulletin CHE-R5 pictures and describes maker's ceramic pipes and fittings, valves, towers, exhausters, filters, etc.—General Ceramics Corp., Keasbey, N. J.

Circle **667** on inquiry card.

Containers, Flasks. Seven new bulletins describe maker's "Supairco" containers and flasks for liquid oxygen, air, nitrogen, hydrogen and helium.—Superior Air Products Co., 132 Malvern St., Newark 5, N. J.

Circle **668** on inquiry card.

Precision Springs. New 10-page illustrated data sheets describe modulus and physical properties of spring materials.—Hunter Spring Co., Lansdale, Pa.

Circle **669** on inquiry card.

Cap Nuts. New 2-page bulletin presents schematic drawings and tables of stock sizes and dimensions for maker's zinc-alloy cap nuts.—Gries Reproducer Corp., 125 Beechwood Ave., New Rochelle, N. Y.

Circle **670** on inquiry card.

Tape Labels. New 8-page leaflet pictures and describes maker's "Print-Stix" and "Cal-Stix" transparent and metallic acetate-film used for identification.—Topflight Corp., York, Penna.

Circle **671** on inquiry card.

Fastenings. New 24-page Catalog 55A presents maker's complete line of stainless-steel fastenings; including cap screws, nuts, washers, etc.—Star Stainless Screw Co., 699 Union Blvd., Paterson 2, N. J.

Circle **672** on inquiry card.

MATERIALS

Lubricants. New 2-page Bulletin 105 describes maker's "Type 165X" and "LOEX Molykote" lubricants.—Alpha Molykote Corp., 65 Harvard Ave., Stamford, Conn.

Circle **673** on inquiry card.

Metal Coating. New 4-page brochure describes maker's "Laqua" metal coating which preserves chemically cleaned surfaces.—Fidelity Chemical Products Corp., 470-474 Frelinghuysen Ave., Newark 5, N. J.

Circle **674** on inquiry card.

Rubber Parts. New 4-page brochure describes maker's rubber and rubber insulated metal parts.—Automotive Rubber Co., Inc., 12550 Beech Road at P.M.R.R., Detroit 39, Mich.

Circle **675** on inquiry card.

Synthetic Quartz. New 8-page issue of "Brush Strokes" (Vol. 4, No. 1) features article on "Electronic Grade Synthetic Quartz."—Brush Electronics Co., 3322 Perkins Ave., Cleveland, Ohio.

Circle **676** on inquiry card.

FABRICATION

Machine Tools. New 8-page brochure "Hirschmann-Highlights" describes and illustrates "Hauser's 3BA" jig borer, "Tornos' " swiss-type automatic screw machine, "Schaublin 102-80" lathe cabinet stand, etc.—Carl Hirschmann Co., 30 Park Ave., Manhasset, N. Y.

Circle **677** on inquiry card.

Bobbin Winder. New 2-page data sheet describes maker's "Model 314-AM3" front-loading multiple-head adjustable-length bobbin winder.—George Stevens Mfg. Co., Inc., Pulaski Rd. at Peterson, Chicago 30, Ill.

Circle **678** on inquiry card.

Solder Fluxes. New 2-page bulletin describes maker's "Lotemp" paste solder and "solderux" fluxes.—Mico Instrument Co., 80 Trowbridge St., Cambridge, Mass.

Circle **679** on inquiry card.

Welding Process. New 8-page leaflet describes maker's welding kit, electric welding gun, spray unit, etc.—American Agile Corp., 5461 Dunham Rd., Maple Heights, Ohio.

Circle **680** on inquiry card.

Impregnating Machine. New 4-page illustrated bulletin describes maker's "Model 10 SH" impregnating machine for impregnation under vacuum.—Red Point Products, Inc., 1907 Riverside Drive, Glendale 1, Calif.

Circle **681** on inquiry card.

Stamping Directory. New 72-page "First-Precision Stamping Directory" presents list of manufacturers having stamping facilities used for precision metal parts.—American Silver Co., Inc., 36-07 Prince St., Flushing 54, N. Y.

Circle **682** on inquiry card.

Drafting Instruments and Supplies. New 16-page booklet describes maker's instruments and supplies for engineers, draftsmen, architects, designers, etc.—Way-Mac Manufacturing Co., 8124 Melrose Ave., Los Angeles 46, Calif.

Circle **683** on inquiry card.

Drafting Templates. New 12-page Catalog 57 presents list of 64 drafting templates for engineers, draftsmen, architects and designers.—Rapidesign, Inc., Box 592, Glendale, Calif.

Circle **684** on inquiry card.

Rotary Table. New 2-page Bulletin 594 presents specifications of maker's 42" precision plain rotary table.—Pratt & Whitney Div., W. Hartford 1, Conn.

Circle **685** on inquiry card.

Machine Tools. New 24-page illustrated catalog describes maker's automated transfer-type, line-index, trunnion-type and rotary-index special machine tools.—Snyder Tool & Engineering Co., 3400 E. Lafayette Ave., Detroit 7, Mich.

Circle **686** on inquiry card.

Soldering Irons. New 2-page data sheet presents specifications of maker's "Type 200" soldering irons.—Kwikheat Mfg. Co., 3732 San Fernando Rd., Glendale 4, Calif.

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Production Facilities. New 32-page booklet describes maker's production process and service facilities for precision electromechanical equipments.—Allied Products Div., Hamilton Watch Co., Lancaster, Pa.

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Wallace & Tiernan Incorporated 1823
Weksler Thermometer Corp. 1911
Welch Scientific Company, W. M. 1861
Weston Electrical Instrument Corporation 1831
Wheelco Instruments Div., Barber-Colman Company 1907
Winzeler Manufacturing & Tool Co. 1955

Z

Zeiss, Inc., Carl 1968

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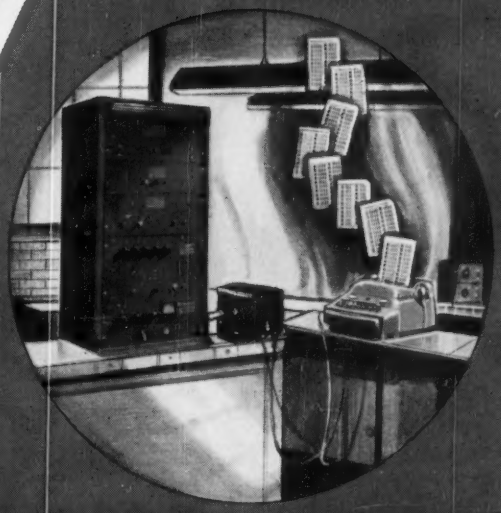

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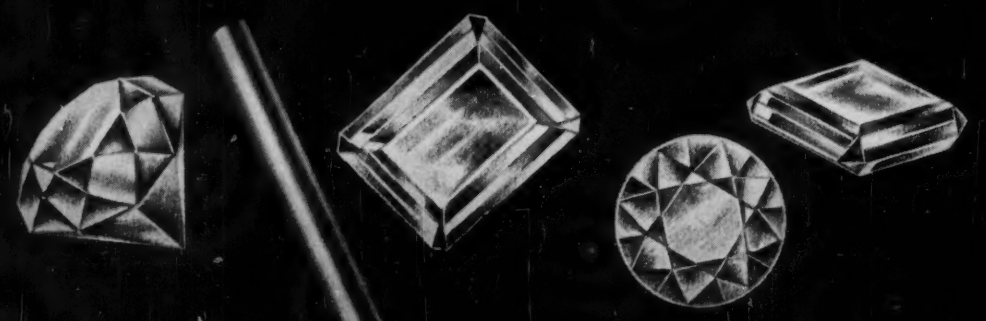

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